APR 29 1925

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See advertisement page 75.
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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
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See half-page Advert. last week and next week. 2781

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Thos. Piggott & Co., Limited,
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See Advertisement last week, page 13.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page 36, April 10.* 1994
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Specification and Workmanship equal to Main Line Locomotives.
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SPECIALISTS
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PLANT AND MACHINERY
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ENGINEERING WORKS,
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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
The Scottish Tube Co., Ltd.
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 61, April 10.

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PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 2276

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Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
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For Boilers of all types.
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Naval Outfits a Speciality,
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Supplied to the British and other Governments.
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1794

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AND PROPULSION PROBLEMS.
Special designs only.
"Circulation Theory."
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ENGINES, 500 Kw., Dynamos 230 Volt D.C. Brush, Parsons 500 Kw., EXHAUST TURBINE SET 220 Volt, D.C., with complete condensing plant. Very low price.
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GENERAL CONSTRUCTIONAL ENGINEERS. 1216
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IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 53. 2584

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 49, April 10.

New Wire Ropes,
Half price. Send for list.
LONDON ELECTRIC FIRM.
Croydon. 2722

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Very Fine, Almost Equal New
14 HP. MARSHALL DOUBLE CYLINDER PORTABLE ENGINE AND BOILER. 120 lbs. working pressure. Colonial Type Firebox.
NEARLY NEW, 21 in. by 12 in. BROADBENT STONE-BREAKER, ONLY WORKED SIX MONTHS.
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Main Feed Pumps.
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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES } Rowe's Patents.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
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LAND AND MARINE
YARROW BOILERS. 2277

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Walter Somers, Limited,
HALESOWEN. 7116
Matthew Paul & Co., Ltd.,
LEVENFORD WORKS Dumbarton. 2212
See Full Page Advt., page 58, March 27.

Taylor & Challen
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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 80, March 27. 5196

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LIMITED.
See Advertisement page 62. 2402

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T. SUMMERSON & SONS, LIMITED
DARLINGTON. 2702

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS,
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
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Works and Offices: 120, Cornwall Street, Glasgow.
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New 300 & 500 B.HP. M.A.N.
STATIONARY DIESEL ENGINES with accessories, as delivered from the makers under Peace Treaty; also Dynamos for same. All spare parts in stock.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Victoria Street, E.C. 4. 2527

For Sale or to Feu, in Whole
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68 ACRES OF GROUND AND BUILDINGS, suitable for Factories or Works, at Inchinnan, on the main road between Glasgow and Greenock.
One building, length 250 ft. by 150 ft., height 48 ft. to eaves, structure of brick and steel, lit from roof, contains approximately 37,500 sq. ft. floor space.
One building, in several bays, 330 ft. long at the longest part, 268 ft. broad, height, one part 24 ft. 6 in. to eaves, other part 16 ft. to eaves, structure of brick and steel, lit from sides and roofs, granolithic floors, mechanically heated, contains approximately 83,000 sq. ft. floor space.
One building 320 ft. long by 160 ft. broad, height, 16 ft. 9 in. to eaves, with small annex 50 ft. by 30 ft., structure of brick and steel, granolithic floors, lit from sides and roof, mechanically heated, approximately 53,000 sq. ft. floor space.
Electric power is laid into each of these buildings from the Clyde Valley Power Station, also water supply.
For further particulars apply to:—
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The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by SIR WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2701

ROYAL CORPS OF NAVAL CONSTRUCTORS.

A Competitive Examination for one or more posts as PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the Royal Naval College, Greenwich, in June next.

The Regulations and full particulars of the salary, prospects of promotion, etc., may be obtained from the Secretary (C.R.), Admiralty, S.W.1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience, not later than 23rd April.

Preference will be given to ex-service men.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE.

In conjunction with the above examination, there will be a Qualifying Examination for the admission of Private Students of Naval Architecture to the Royal Naval College, Greenwich. Applications for the Regulations, etc., should be made as in the case of the examinations for the post of Probationary Assistant Constructors (see above).

Private Students are at present required to pay a fee of £30 a session whilst at the College, but this fee will probably be increased in the near future. H 726

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech., London Univ. (Matric., Inter., B.Sc.), Inst.M. & Cy.E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc.M.Inst.C.E., Chartered Civil Engineer. M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 2689

Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London S.W.1. G 758

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2676

TENDERS.

COUNTY BOROUGH OF BURNLEY.

TO PUBLIC WORKS CONTRACTORS.

The Corporation invite

Tenders for the Construction

of a NEW AQUEDUCT, to carry the Leeds and Liverpool Canal over Yorkshire Street, Burnley, to replace the existing Stone Culvert. The work consists of a steel trough to carry the waterway 70 ft. clear span, with reinforced concrete paths and parapet walls, and the necessary abutment and wing walls, etc.

Drawings may be inspected, and Conditions of Contract, Specification and Bills of Quantities may be obtained, upon application to the Borough Engineer and Surveyor, Town Hall, Burnley.

The lowest or any Tender will not necessarily be accepted, and only Tenders from firms experienced in this class of work will be considered.

COLIN CAMPBELL,
Town Clerk.

Town Hall,
Burnley.
April, 1925. H 755

METROPOLITAN ASYLUMS BOARD.

TO ENGINEERS.

The Board invite separate

Tenders for :—

A. GENERAL ENGINEERING WORK, including Steam Plant, Steam and Condense Mains, Heating and H.W.S. Mains and Apparatus, Electric Motor-drives for Deep Well Engines and Laundry, etc.
B. INSTALLATION OF FOUR NEW LANCASHIRE STEAM BOILERS.
C. INSTALLATION OF NEW FUEL ECONOMISER.
D. BUILDING BRICKWORK SETTINGS for Four Boilers and Fuel Economiser.
E. INSTALLATION OF NEW LAUNDRY MACHINERY AND PLANT.
F. INSTALLATION OF ELECTRICAL GENERATING PLANT, MOTORS AND POWER WIRING, at Leavesden Mental Hospital, King's Langley, Herts; each in accordance with the Specification and Drawing/Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief.

The Specification, Bills of Quantities, Drawing/Drawings, and Forms of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Wednesday, 15th April, 1925, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification, Bills of Quantities, and the Drawing/Drawings has/have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board, not later than 2.30 p.m., on Wednesday, 29th May, 1925.

G. A. POWELL,
Clerk to the Board.
H 752

CONDENSING PLANT AND MOTORS FOR SALE.

Sealed Tenders will be received by the DIRECTOR OF ARMY CONTRACTS up to Eleven o'clock a.m., on the 29th April, 1925, for the following :—

TWO SETS SURFACE CONDENSING PLANT, complete with Edwards Patent Enclosed 3-cylinder Air Pump and external Condensate Pump.

TWO ELECTRIC MOTORS, each 11 HP. shunt wound 170 r.p.m., 500 volts, D.C.

TWO DRUM TYPE STARTERS for above motors.

The plant, etc., is at the Royal Arsenal, Woolwich.

Forms of Tender may be obtained on application to the DIRECTOR OF ARMY CONTRACTS (D.C. Sales), Caxton House, West Tothill Street, S.W.1. H 677

COUNTY BOROUGH OF STOKE-ON-TRENT.

ELECTRICITY DEPARTMENT.

PUMPS, CAST IRON PIPING, VALVES, CHLORINATING PLANT, ETC.

CONTRACT NO. 2513.

Tenders are Invited for the

SUPPLY and ERECTION of all the PLANT and MATERIALS for a WATER PUMPING SCHEME. The Contract will include the supply and laying of about 1400 yards of 6-inch internal diameter cast iron water pipe, laid partly in public roads and partly in private land. Tenders must include for the laying of this piping. Tenders for supply only of piping will not be considered. It is desired to deal with the contract as a whole, but consideration may be given to Tenders for separate sections.

Specification, including forms of Tender, drawings, etc., can be obtained from the Borough Electrical Engineer, St. George's Chambers, Wolfe Street, Stoke-on-Trent, on deposit of £2, returnable on receipt of a *bona fide* Tender.

E. B. SHARPLEY,
Town Clerk.

Town Hall,
Stoke-on-Trent.
7th April, 1925. H 742

For Disposal by Tender,

40,000 tons (ex-German) FLOATING DOCK, No. 23.

THE ADMIRALTY have for disposal, without restriction as to use abroad, the above-mentioned Dock, lying in sections at Chatham.

Brief particulars of the Dock are as follows :—

Lifting Capacity	40,000 tons.	
Length overall	702 ft.	9 ins.
Breadth	194 ft.	
Breadth to outside walls	183 ft.	10 ins.
Width inside at top of walls	154 ft.	2 ins.
Width inside at bottom of walls	147 ft.	10 ins.
Minimum inside width (between fenders)	147 ft.	2 ins.
Length of M.L. Keel Blocks	700 ft.	
Height of Blocks	4 ft.	3 ins.
Maximum draught of ship dockable, about	36 ft.	
Depth of water required at site to dock ship of 36 ft. draught	63 ft.	6 ins.
Time for lifting large ship	2—3 hours.	

The sections of the Dock are for sale as and where they lie, and without any guarantees. Further particulars, Tender Forms, Conditions of Sale, etc., together with an order to view, may be obtained upon application to the DIRECTOR OF NAVY CONTRACTS, ADMIRALTY, Room 62, Princes House, Kingsway, London, W.C.2.

Sealed Tenders are due at the Admiralty by Noon, on Tuesday the 12th May, 1925. H 758

LIFFEY TUNNEL.

THE DUBLIN PORT AND DOCKS BOARD invite

Tenders from Responsible and

Experienced Contractors for the CONSTRUCTION of a SUBWAY under the River Liffy, at Dublin.

Applicants must submit with their Tender a statement of their previous experience of subaqueous tunnelling, together with a list of the works carried out by them and the contract price of same. No Tenders will be entertained from firms which have not had experience as principal contractor on such works.

The works to be carried out will comprise the following :—

The construction of—

(a) Two 18 ft. 0 in. internal diameter Shafts, about 70 ft. deep.
(b) One 11 ft. 9 in. internal diameter Iron-lined Tunnel, about 850 feet in length.
(c) Two Shaft Houses with all fittings.
(d) Two Electric Lifts and Two Stairways.
(e) Ventilation and Lighting System in Tunnel and Shafts, and all other fittings shown or specified.
(f) All Temporary Works, Compressed-Air Plant, etc., necessary for the execution of the contract.

Specification, Drawings and Form of Tender may be obtained on application at the Engineer's Office, Dublin Port and Docks Board, East Wall, Dublin, on and after the 18th April, 1925, between the hours of Ten a.m., and Four p.m. Such applications must be accompanied by a receipt from The Secretary to the Board for a deposit of £10, which must be lodged with the Secretary, Dublin Port and Docks Board, Westmoreland Street, Dublin. This deposit will be refunded on receipt of a *bona fide* Tender, accompanied by all drawings and documents obtained from the Engineer.

Tenderers desiring to have extra copies of any of the drawings to assist them in preparing their Tender will be supplied with such copies on payment of a sum of 5s. per sheet, which sum will not be returned. All drawings so supplied must be returned under separate cover at the same time as the Tender is submitted.

Tenders must be delivered under seal, addressed to THE SECRETARY, Dublin Port and Docks Board, Westmoreland Street, Dublin, and endorsed "Tender for Liffey Tunnel," not later than Eleven a.m., on Tuesday the 19th May, 1925. No Tender will be entertained unless so delivered.

The Board do not bind themselves to accept the lowest or any Tender.

Port and Docks Office,
8th April, 1925. H 751

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon, on Friday, 8th May,

Tenders for the Supply of :—

1. LOCOMOTIVE BOILERS ;

and up to Noon, on Wednesday, 6th May, Tenders for :—

2. STEEL MATERIAL (CHANNELS, ANGLES, PLATES, ETC.).
3. CRANK AND STRAIGHT AXLES FOR LOCOS.
4. COPPER FIREBOX PLATES.
5. STEEL BOILER TUBES.
6. FENCING MATERIALS.
7. GALVANISED STEEL OR IRONWORK.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 20/- each for Nos. 1, 2 and 3, and 10/- each for Nos. 4, 5, 6 and 7 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices : 91, Petty France,
Westminster, S.W. 1.
15th April, 1925. H 774

APPOINTMENTS OPEN.

Civil Engineer Required

by the GOVERNMENT of UGANDA, for the PUBLIC WORKS DEPARTMENT, for a tour of 20 to 30 months' service. Salary £400, rising by annual increments of £20 to £500, and thence by annual increments of £25 to £600 a year, plus a temporary allowance of 20 per cent. at present authorised to the 30th June, when the matter of its continuance or otherwise will be considered. Free passages and liberal leave on full salary. Outfit allowance of £30 on first engagement. Candidates, aged 25 to 30, should have served articles with a Civil Engineer of standing and be an Associate Member of the Institution of Civil Engineers or hold equivalent professional qualifications. Should have had, as Assistants, experience of building and road construction, including bridge work, also drainage and water supply if possible. Training and experience in a Municipal Engineer's office would be suitable.—Apply, at once by letter, stating age, qualifications and experience to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W.1, quoting M/13487. H 776

COUNTY OF LONDON.

HOUSING DEVELOPMENT SCHEMES—APPOINTMENT OF AN ASSISTANT TO ADMINISTRATOR.

The London County Council invites

Applications for the Position

of an ASSISTANT to the ADMINISTRATOR OF HOUSING DEVELOPMENT SCHEMES. The appointment will be a temporary one. The person selected will be required to act as an assistant to the Administrator in the control and supervision of the large contracts of housing development schemes entered into by the Council. Candidates should have been trained either as Civil Engineers or Architects, and have had considerable experience in the conduct of large construction works. Experience as a Resident Engineer or as an Architect with outdoor experience on large construction works is required, and commercial knowledge gained on the staff of a large contractor would be a qualification. Preference will be given to candidates who have served, or attempted to serve, with His Majesty's Forces. Applicants who did not so serve must be natural-born British subjects. The salary offered is at the inclusive rate £750 a year. Application forms can be obtained from the Administrator of Housing Development Schemes, The Old County Hall, Spring Gardens, S.W.1, to whom they must be returned not later than Eleven a.m., on Friday, 24th April, 1925. Stamped foolscap envelope necessary. All communications must be marked "Assistant to Administrator." Canvassing disqualifies.

MONTAGU H. COX,
Clerk of the London County Council.
H 750

MUNICIPALITY OF GEORGE TOWN, PENANG, STRAITS SETTLEMENTS.

ASSISTANT ENGINEER.

The Municipal Commissioners of George Town, Penang, require an

Assistant Engineer, age 25 to

32, preferably unmarried, on a three years' agreement with possible extension. Applicants must have had a good technical education and a regular training as pupil and assistant in a Municipal or County Engineer's Office, with experience in Municipal and general engineering work, including Roads, Buildings, Bridges, Sewerage and Conservancy details, and the control of workmen. Preference will be given to candidates who have a knowledge of the design of Sewage Works and who have passed the Testamur Examination of the Institute of Municipal and County Engineers.

Salary, $5400 for the first year, rising if the officer remains in the service by biennial increments of $300 a year to a maximum of $9000 per annum, paid monthly in dollars, the currency of the Colony, the value of the dollar being 2s. 4d. sterling. The pay of the appointment at this rate for the first year would be £630. An allowance for the maintenance of a motor car when on duty will be granted. Free passage will be provided, with half-pay during the voyage out. The selected candidate must pass an approved medical examination.

Applications, stating whether married or single, age, birthplace, and giving details of education, training and experience generally, with particular reference to the items mentioned above, and copies (only) of testimonials, to be lodged with Messrs. PURCH & WILLIAMS, M.M.Inst.C.E., 180, Hope Street, Glasgow, agents for the Commissioners (who will give further particulars if requested), not later than Tuesday, 21st April, 1925. H 729

Office and Sales Manager

REQUIRED for Engineering Business concerned mainly with chemical and allied industries. Good commercial experience backed by Engineering and Chemical training essential ; knowledge French and German desired. Fullest particulars, copies of recent testimonials and salary required.—Address, H 754, Offices of ENGINEERING.

R. Y. Pickering & Co., Ltd.,

Railway Carriage and Wagon Builders, Wishaw, near Glasgow, have VACANCY for a WORKS MANAGER of sound Technical, Engineering and Drawing Office experience, fully conversant with the manufacture of Railway Carriages and Wagons in all its branches, good organiser, able to control labour.—Apply, stating age, qualifications, salary required, when at liberty, and forward copies of recent testimonials, to JOHN ALSTON, Mgr., Municipal Buildings, Coatbridge, Lanarkshire. H 736

Qualified Accountant, fully

experienced in Engineering Works Accountancy, Production and Costing, REQUIRED for Provinces. Permanency.—Address, H 770 Offices of ENGINEERING.

Engineer (Outside Structural

SUPERVISOR) REQUIRED, capable organising rapid erection of large contract. State age, experience and salary.—Address, H 702, Offices of ENGINEERING.

Wanted for Natal, as Assis-

tant Factory Manager, FIRST-CLASS ENGINEER with good experience of distillation and evaporating process. Salary £800 per annum. Appointment offers opportunity of advancement.—Write, G.R., c/o J. W. VICKERS & Co., Ltd., 9, Nicholas Lane, E.C.4. H 744

Engineer, Understanding

Manufacture of Domestic and Range Boilers, capable of taking full control of works. Commercial knowledge an advantage.—Address, H 772, Offices of ENGINEERING.

Wanted for Bolivia, Capable

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SALARY : Rupees 450, or according to age and qualifications, rising by annual increments according to the Rules in force, to Rs. 1100 per calendar month.

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S. G. S. YOUNG,
Secretary.

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THE WAR FLEETS OF THE NATIONS.

THE annual return presented to Parliament, entitled "Fleets (The British Empire and Foreign Countries)," is generally worthy of close attention, for it shows almost at a glance the relative strengths of the navies of the Powers. It also indicates, by the numbers and types of warships building and projected, the trend of naval opinion in the different countries, and especially in the case when, as at present, expenditure is very strictly limited in all countries, and only vessels considered most necessary are laid down. The reported intention of President Coolidge to call another conference, for the consideration of further limitation of naval armaments, renders the return for the present year of more than ordinary interest, for the information it contains must form the basis on which decisions are likely to be reached.

Events have moved so rapidly in these later times that it hardly seems four years ago that the then President of the United States called a conference of the Powers, which resulted in the Washington Naval Treaty. Yet such is the case, although the time taken in the necessary formalities by which the Parliaments of the various countries endorsed the action of their representatives at the conference postponed the effective date of the Treaty to August 23, 1923. It remains in force until the end of 1936, and in the interval the signatory powers bind themselves to abide by its provisions. It will be remembered that by the Treaty, limits are placed on the tonnage of individual units, on the largest calibre of gun mounted, and on the total tonnage possessed by each nation, of both capital ships and aircraft carriers, the two largest types of war vessels. The Treaty by implication also limits the tonnage of any light cruiser which may be constructed and the calibre of its largest guns. Although some attempt was made at the Conference to limit the total tonnage of this type of warship, and also that of submarines, no agreement was reached. Presumably the next Conference will reconsider these matters and endeavour to arrive at a satisfactory result.

So far as capital ships are concerned, the Treaty limits the standard displacement to 35,000 tons per unit, the calibre of gun to 16 in., and the total tonnage to 525,000 tons each for the United States and the British Empire, 315,000 for Japan, and 175,000 each for France and Italy, these figures corresponding to ratios of 15 : 9 : 5. For aircraft carriers the maximum tonnage of a unit is 27,000 standard tons, the largest calibre of gun 8 in., and the total tonnage allocated to the United States and the British Empire 135,000 tons each, Japan 81,000, and France and Italy 60,000 tons each. The ratios are here 15 : 9 : 6⅔. France and Italy obtaining a one-third larger ratio for this type than for capital ships. Although 27,000 tons is the maximum tonnage allowed, it was agreed by the Conference that any of the Powers could build one or two carriers of 33,000 tons, provided the total tonnage was not exceeded. This provision was included to meet the convenience of the United States, whose naval authorities, for reasons of economy, desired to convert the battle cruisers Lexington and Saratoga, of 33,000 tons displacement, to aircraft carriers. By Articles XI and XII of the Treaty no vessel exceeding 10,000 tons standard displacement, other than a capital ship or aircraft carrier, or carrying a gun greater than 8 in. calibre, other than a capital ship, is to be laid down by any of the signatory Powers whilst the Treaty remains in force. These two articles thus fix the maximum displacement of light cruisers to 10,000 tons and the largest gun carried in them to 8 in. The standard displacement is very nearly that of the ship fully completed, but without oil fuel and reserve feed water for boilers.

The provisions of the Treaty outlined above are useful to remember when studying the contents of the Parliamentary Return referred to at the outset. A summary shows the numbers of completed vessels in the navies of the Powers, and the numbers under construction and projected. These are as follows: British Empire, 497 and 20; United States, 539 and 44; Japan, 211 and 67; France, 219 and 126; Italy, 260 and 58; Russia, 164 and 35; and Germany, 51 and 2. Judged by completed numbers the British Empire takes second place to the United States; for vessels under construction and projected it is last on the list, except for Germany. Of the 20 British ships now being constructed six were laid down during the War, two others are coastal motor boats.

If, however, the numbers of capital ships, aircraft carriers, cruisers, Flotilla leaders, destroyers, torpedo boats, and submarines are taken, the British Empire has 348 completed; the United States, 478; Japan, 192; France, 126; and Italy, 193.

The return shows that in capital ships, the British Empire, United States, and Japan have the numbers and individual ships agreed to at the Washington Conference, but France has one less—the La France sunk by striking a rock in August, 1922—and Italy three less, *viz.*, the Leonardo da Vince, Vittorio Emanuele and Regina Elena. It was stated at the time of the La France's loss that she would be replaced by a new ship but no steps have been taken to carry this into effect. The numbers of battleships in the various navies are British Empire 18, United States 18, Japan 6, France 9, Italy 7, Russia 3 and Germany 8, whilst the British Empire and Japan have each four battle-cruisers. The capital ships of the United States are of newer construction than those of other Powers, seven having been completed since 1917. Japan has three completed since that year and the British Empire one, the Hood. The average age, reckoned from the date of completion, of the United States capital ships is 8 years, compared with 10 for the British Empire, 8½ for Japan, 12 for France, and 13 for Italy. The capital ships of the British Empire carry altogether one hundred 15-in. and eighty-eight 13½-in. guns; those of the United States, twenty-four 16-in., one hundred and twenty-four 14-in. and fourty-four 12-in.; those of Japan sixteen 16-in. and eighty 14-in.; those of France thirty 13·4-in. and forty-eight 12-in.; and those of Italy sixty-eight 12-in. and twenty-four 8-in. guns. The battleships of the American Fleet have a maximum speed of 20½ to 21 knots, of Japan 22½ to 23, of the British Empire 21 to 25, of France 19½ to 20, and of Italy 21½ to 23 knots. The British battle cruisers have speeds of over 30 knots and those of Japan 27½. Only three capital ships are under construction at the present time, the Nelson and Rodney laid down in 1922, and the Russian Demokratuga started in 1914, but unlikely to be completed. When the two British battleships are passed into commission, four of the older ships will be scrapped.

Of the battle-cruiser type, the British Empire and Japan are the only two powers which have examples. The Saratoga and Lexington laid down in 1920 by the United States were designed as battle-cruisers, but are now being converted.

Dealing next with cruisers, the return shows that the British Empire has 49 completed and 8 building and projected. These figures compare with 31 and 9 for the United States, 28 and 11 for Japan, 16 and 9 for France, 13 and 5 for Italy, 7 and 7 for Russia, and 8 and 1 for Germany. The eight British cruisers building are the Emerald, Enterprise and Effingham, laid down during the war, and five of the Kent class ordered last year. Of the nine United States vessels, the Memphis was started in 1920, eight are authorised, and money has been recently appropriated for two. Nine of the Japanese vessels are building and two projected. France has five cruisers laid down and four more are to be ordered before 1929, whilst Italy has two building and three projected. The total tonnages (*a*) of completed cruisers, (*b*) of those which, having been completed fifteen years, are now considered obsolete, and (*c*) of those building and projected are given in the following table:—

Nation.	(*a*) Completed Tonnage, Modern and Obsolete.	(*b*) Obsolete Tonnage.	(*c*) Building and Projected Tonnage.	*a*+*c*−*b*
British Empire ..	234,000	38,000	75,000 (?)	271,000
United States ..	252,000	184,000	87,500	155,500
Japan	166,000	75,000	85,000	176,000
France	150,000	100,000	84,000	134,000
Italy	68,000	10,000	50,000	108,000

The displacement of the Kent class is not stated in the return, and in the table is taken as 10,000, the maximum allowed and as shown for the latest cruisers of all the other Powers. Five each of the French and Italian cruisers are surrendered German and Austrian vessels.

It is interesting to speculate on the direction in which the next Washington Conference, if held, will move in connection with cruiser tonnage. If the 5 : 5 : 3 ratio adopted for capital ships and aircraft-carriers is suggested and agreed to, there must result a great scrapping of British and Japanese tonnage, or a large building programme for the United States. On the other hand, the British representatives may urge the ocean routes, which must be protected to ensure an adequate food supply to this country, necessitate a much larger ratio than to the United States and Japan, for which conditions are different. The problem of arriving at a conclusion agreeable to all promises to be a difficult one.

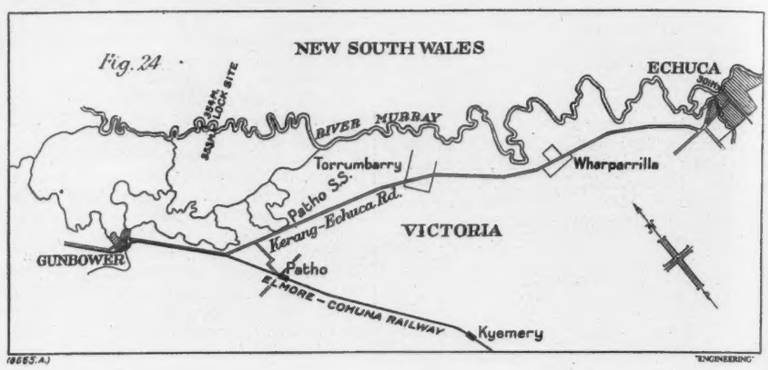
Of cruiser mine-layers only one is referred to in the return, and this is the British Adventure, laid down in 1922, but of which no details are given.

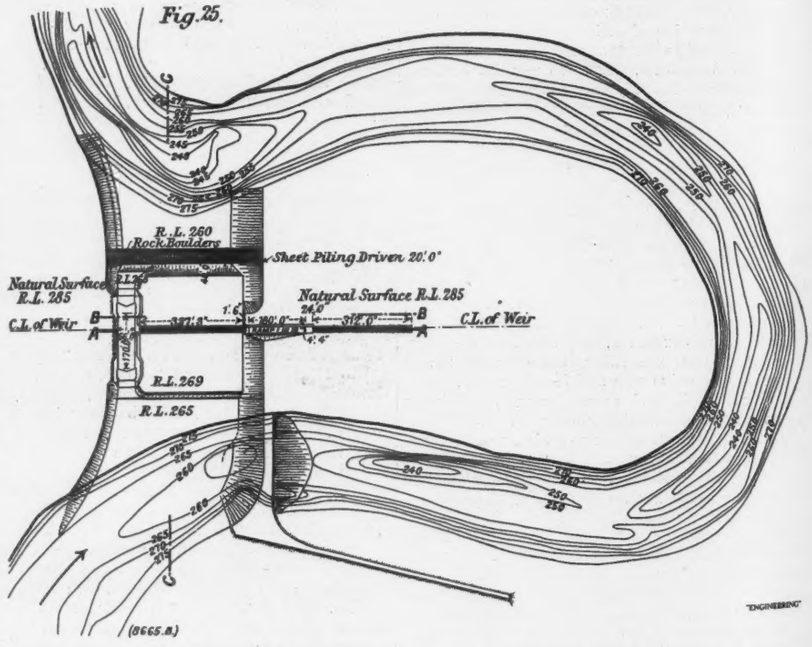
The British Empire is credited with the greatest number, eight, of aircraft-carriers, all of which are recorded as built. The United States and Japan have each two completed and two building, whilst France and Italy have no vessels of the type built and only one each building. Of the total of 18 aircraft-carriers mentioned, only two, the Hermes and Hosho, were designed for the purpose, the remainder are converted vessels. The eight of the British Empire are the Glorious, Courageous, Furious, Hermes, Eagle, Argus, Pegasus and Ark Royal, the total tonnage being 114,000 tons. Of these, the two first are under conversion, and until they are completed the tonnage afloat will be 77,000, or rather over one-half the amount allowed by the treaty. The Wright and Langley, the two completed American vessels, have a tonnage of 24,000 and a speed of 15 knots. With the Saratoga and Lexington completed the total tonnage will be 90,000. The Hosho and Wakamiya, of the Japanese Navy, are of 15,000 tons total, the first named having a speed of 25 knots. The Akagi, a battle cruiser, and the Kaga, a battleship, each of 27,000 tons, are being converted to aircraft-carriers. The French are converting the battleship Béarn, of 21,000 tons, and the Italians a merchant ship of 5,000 tons for the same purpose. It is evident the three strongest naval Powers anticipate that the aircraft-carrier, a type unknown at the outbreak of war in 1914, will play an important part in future naval warfare.

Interesting figures are given in relation to the torpedo craft—flotilla leaders, destroyers, torpedo boats and submarines—of the various navies. Flotilla leaders are a type first used in the British Navy, the earliest being ordered just before the war. They are the leaders and flagships of the torpedo flotillas, and for this reason are larger and faster than destroyers. The British Empire has 17 completed and one—the Keppell—laid down in 1918 still under construction. The American and Japanese Navies have no vessel of the type, and are not building or proposing to build any. The French have one, a surrendered German vessel, and the Italians nine, four being of small tonnage. The French naval authorities have, however, adopted the type, are building six, and 15 more are to be laid down before 1929. Those under construction are powerful vessels of 2,360 tons displacement, 50,000 h.p., 35½ knots speed, with five 5·1-in. guns, and six torpedo tubes. The largest British vessels are of 1,800 tons, 40,000 h.p., 36½ knots speed, with five 4·7-in. guns and two triple torpedo tubes. Italy is building two of the type, of 2,200 tons each, 50,000 h.p., 35 knots speed, and eight 4·7-in. guns. In torpedo boat destroyers the United States hold a big lead, 309 being completed and 12 projected. The British Empire follows with 189 and 2; whilst Japan has 101 completed and 23 building and projected. The corresponding numbers for France are 54 and 36, for Italy 53 and 24; and for Russia 80 and 26. The total completed tonnages, including flotilla leaders, are as follows: United States, 355,000 tons of which by far the greater proportion have been completed since 1917; 15,000 tons have been completed over 12 years and are, therefore, considered obsolete. The tonnages of the other

THE REGULATION OF THE MURRAY RIVER.

(For Description, see opposite Page.)





Powers are: British Empire, 234,000; Japan, 88,000, including 9,500 obsolete; France, 41,000, 7,500 obsolete; and Italy, 39,000, of which 2,700 is out of date. Japan has under construction 8 destroyers of 1,400 tons each, and 15 others are authorised; France has laid down 18 of about 1,450 tons, and contemplates another 18 before 1929; Italy has 8 under construction, and 8 others ordered.

The only navy possessing torpedo boats is Italy, which has 68 of these craft. No further vessels of the type are being constructed for the Italian or other navies, and in view of this the designation of torpedo boat destroyers is obsolete.

In submarines, the United States also hold a lead, nearly as pronounced as for destroyers since 118 are completed and 15 building and projected. The corresponding figures for other nations are: Great Britain, 63 and 4; Japan, 51 and 28; France, 46 and 59; and Italy, 43 and 20. The completed tonnages are: United States, 80,000, of which 10,000 is stated to be for coast defence only; the British Empire, 53,000; Japan, 30,000, including 1,700 obsolete having been completed over 10 years; France, 30,000, of which 1,700 is obsolete; and Italy, 17,500.

Of the 15 submarines building and projected by the United States, three fleet submarines of 2,200 tons surface displacements, and three of 900 tons are under construction, five more of the former type are authorised but not laid down, and four more are projected. Of the four building for the British Empire two were laid down in 1918—X1 in 1922 and O1 in 1924. Japan laid down eight of over 1,000 tons last year, four of a smaller type are also building, and 16 are authorised. France has embarked on a very extensive submarine programme, two of 1,360 tons, nine of 1,130, and 18 of 590 having been laid down since 1922. Two cruiser submarines of 3,000 tons each, and 34 of ordinary type are to be ordered before 1929, whilst three of 590 tons, termed second class, are to be laid down each year. Italy has placed orders for 12 submarines, four being of 1,300 tons, four of 800, and four of 780, and eight others are projected. These figures show very clearly that large programmes of submarine construction are contemplated by nearly all the Powers.

Six other types of war vessels are included in the return, viz., coast defence vessels, sloops, coastal motor boats, gunboats, and despatch vessels, river gunboats, and minesweepers. In all these classes, with the exception of gunboats and despatch vessels, the British Empire leads in numbers. In coast defence vessels the British have three, the only other being one possessed by the United States. The British Navy has 35 sloops, and the French 8; 29 coastal motor boats, Japan and France 2, and Italy 12; 2 gunboats and despatch vessels, and France 49; 18 river gunboats, and Japan 8; 62 minesweepers, the United States having 45, Japan 3, France 29, and Italy 40. In this last type which was shown to be very necessary by war experience, are all relatively new vessels.

A close study of the contents of this Parliamentary Return leaves many impressions, but amongst these the strongest are the marked superiority of the American Navy in all types of war vessels, with the exception of cruisers and aircraft carriers; the increasing importance of aeroplanes in future naval operations expected by the three leading Powers, but not apparently by France and Italy; the activity in torpedo craft construction by all the Powers, with the exception of the British Empire, and the increasing tonnage of individual units; and finally, the relatively small programme of British new construction. This last impression is undoubtedly a result of financial stringency, a cause which appears to have little influence on new construction in other countries.

UNITED STATES RAILWAY ARTILLERY.

To the careful observer who has had the opportunity of studying military conditions in the United States it will be evident that the outstanding lesson of the Great War—the need for preparedness—has been thoroughly assimilated by that country. As a result, we find opportunities for training as airmen afforded to civilians, machinery deliberately designed with a view to adaptation for war purposes, intensive research in progress relating to gas warfare, and the production of new and more powerful artillery accelerated. It is to the last development that our attention has been drawn by a series of tests recently carried out on a piece of railway artillery at the Aberdeen proving ground of the United States Army. This particular class of weapon, due to its mobility, proved of immense service to the Turks in their famous defence of Gallipoli peninsula, and at the present time we find a number of the American 14-in. 1920-model guns about to be provided with railway truck mountings, with a view to service under somewhat similar conditions on the Atlantic and Pacific coasts.

One carriage of this kind has already been completed and used in the trials mentioned. It possesses great mobility and can be transported over the usual track, the dimensions and fittings being planned to permit the gun and carriage passing through standard railway clearances. The gun used, we would state, is of 50 calibres and can fire a projectile of 1,560 lb. weight a distance of 45,000 yards, by means of a powder charge of 463 lb. The muzzle velocity of the shell is 2,650 ft. per second, while the tests have indicated the practicability of one shot a minute being discharged. Approximately 70 ft. long, the carriage is supported on bogies which can be removed when a concrete

TORRUMBARRY LOCK AND WEIR; MURRAY RIVER.

Fig. 48. View of Downstream Side from West Bank.

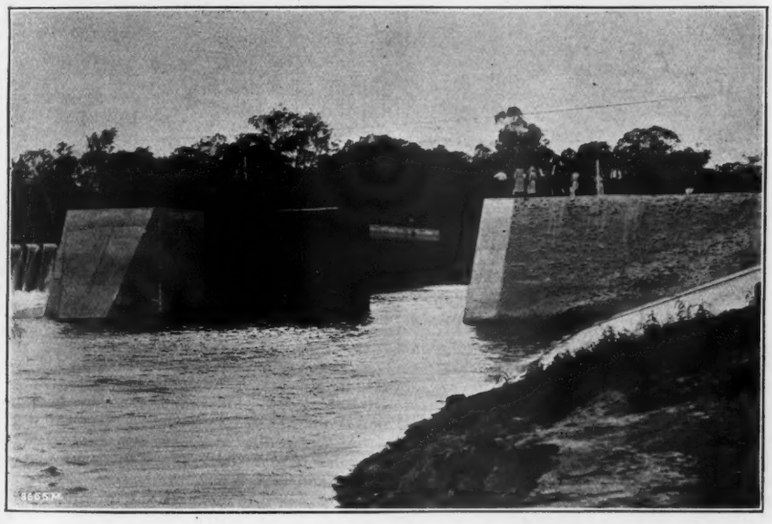


Fig. 49. View of Lower End of Lock.

placing is available. Power, permitting the use of electric motors for elevating the barrel, traversing the carriage, operating the derricks which handle the ammunition, and for compressing the air required for gas ejection, is supplied by a Sterling engine. The latter, with a 50-kw. generator, forms a self-contained unit on a front bogey.

When not required for power purposes, this is disconnected from the rest of the carriage and run away a short distance from it. Flexible electric cables are used to connect the generating plant to the various motors. The loading and maximum firing angles are — 7 and + 50 deg., respectively, while the top carriage circular traverse is 360 deg. on concrete placing and 7 deg. when the gun is on railway lines. The stability of the carriage has been found to be very satisfactory on the ground platform even at low angles of elevation, movement being very slight. Expectations regarding the strength and general utility of the production have been considered to justify the immediate construction of a number of such carriages, guns for which are already in existence. It is intended to send these, when mounted, to the coast defences of Los Angeles where further service tests will be carried out.

THE REGULATION OF THE MURRAY RIVER.

(*Continued from page* 406.)

Of the works higher up the Murray, precedence was given to one which would enable a large irrigable area in Victoria to be developed. This is known as the Kerang district. The site of this is slightly west of north of Melbourne, and, as is shown in Fig. 23, page 468, is some distance from the important railway centre Echuca. In the area in question some 85,000 acres have been under irrigated cultivation by the use of two depressions known as the Kerang Lake and Kow Swamp. A weir has been sited on the Murray so as to ensure flow into these two depressions at all times instead of only at high flood, making gravity irrigation constantly possible, instead of having, as hitherto, to resort to lift irrigation when the Murray was low.

The Torrumbarry Weir and Lock, commanding this area, is the furthest up stream of all these structures on the Murray allowed for in the agreement. It is about 50 miles below Echuca, and ensures a navigable depth of water to that town. This work was completed by the Victoria Constructing Authority in 1923, and has since then been holding the upper pool to a level frequently as high as 15 ft. 6 in. above the lower pool. We are indebted to Mr. J. S. Dethridge, Commissioner for Victoria, for particulars and illustrations of this work. The weir itself is of particular interest, but as the lock is of a standard type, we will describe it first.

At the site the river is very sinuous, as will be seen in Fig. 24. Its width is about 300 ft., while its depth varies from 25 ft. to 45 ft. The formation of the bed and banks is clay, with strata of sandy material at irregular depths. The maximum surface velocity of the stream is 5 ft. per second during floods. At times a good deal of drift timber is brought down. The latter fact decided the authorities to depart from the type of structure previously adopted for the South Australian work, and resulted in the development of a form of weir capable of being completely removed from the waterway during the season of high water, leaving the river clear of piers or other obstructions to the free passage of drift, and having the advantage that no movable parts remain permanently under water and constantly subject to corrosion. The lock, however, is constructed in accordance with the standard designs adopted for the works in South Australia, and is thus similar to the one we described, but did not illustrate, in connection with the weir at Blanchetown. The illustrations we give herewith and on Plate XXX and page 470 of the Torrumbarry lock will thus serve to convey a very good idea of the Blanchetown and other locks both of South Australia and on the higher reaches.

It will be remembered that for locks 1 to 9 inclusive a length of 275 ft. was chosen. For locks above Wentworth, however, the shorter length suggested by Col. Johnston, viz. 170 ft., has been adopted.

The South Australian works, as previously described, have all been undertaken by the means of cofferdams arranged to close off one-half of the river-bed at a time. As mentioned, the works have at times been deluged by flooding. In the case of the Torrumbarry lock and weir it was decided to adopt other measures. After careful consideration of the foundation problem, it was decided to build the work in dry excavation in the neck of a loop rather than in the channel. Risk of flooding was thus avoided and the expense of long cofferdams saved, though, on the other hand, more excavation was involved and a diversion dam also became necessary. As floods occurred during the construction which would certainly have caused a cessation of work in cofferdams, whereas there were no delays of this kind with the method adopted, the Authority has felt satisfied that this scheme was, in the circumstances, the better of the two. Fig. 25, page 468, shows to a larger scale the site indicated in Fig. 24. The new channel lies approximately north-west and south-east. The loop cut out is about six times the length of the new cut. The new channel provides a navigable pass at the weir of 327 ft. 3 in., the depth of the upper pool being 16 ft. The completed work is shown in the views on this page and on page 470. Of these, Fig. 48 is from the down-stream (northern) side of the work, showing the lock in the foreground; Fig. 49 is from a point close by, and shows the lock with the down-stream gates open; Fig. 50 is from the other side of the river, slightly down-stream of the weir and looking over to the lock, while Fig. 51 shows the work at the time of high flood with the navigable pass open; the lock structure is in the foreground.

Details of the lock are given in Figs. 26 to 47, Plate XXX. The lock chamber has a usable length of 170 ft. and a width of 56 ft. The total length of the walls is 305 ft., and their height 23 ft. Fig. 26 shows the lock in plan, and Fig. 27 in longitudinal section. A cross-section at the up-stream end is shown in Fig. 28; one inside the chamber in Fig. 29, and one outside the down-stream gates in Fig. 30. The lock is built on a reinforced-concrete raft with cut-off sheet piling at either end, and along the outer edge of the river wall. On each side in the upper gate recesses are three valve openings for the filling culverts, the latter discharging into the lock through five openings, 24 ft. and 27 ft. apart. The culvert is reduced in capacity as it runs along the side walls. At the down-stream

ends in each gate recess there are, similarly, three culvert openings, one discharge only being placed beyond the gates on each side. Figs. 26, 27, and 29 show the system of drainage adopted below the lock floor. The 12-in. drains deliver to a large cross-collector in communication with the down-stream pool, as shown in Figs. 27 and 30.

The valves for the filling and emptying culverts are illustrated in Figs. 31 to 39. These valves are all standard, 6 ft. by 3 ft., of the butterfly type, and work on vertical spindles, being operated by worm geared hand winches. On the left of Figs. 31 and 33 one valve is shown in the closed position. The other two valves in these drawings are shown open. The valves work in frames set in the concrete, the lower socket for the valve spindle being shown in Figs. 37 and 38. The detail, Fig. 34, illustrates the valve seating on the upstream side of the valve frame. On this side the valve opens outwards. On the other side the valve of course opens inwards; this side seating is shown in Fig. 35. The valves are fitted with rubber strips on their two side faces. At the top and bottom of the frame are face plates supported by rib brackets. These plates are furnished with cast lead fitting strips shown in position in Figs. 33 and 37 and in detail in Fig. 39. The inner face of the valves is fitted on the upstream side with a deflector plate carried on the brackets shown in detail in Fig. 36.

The lock gates are made of iron bark timber with 2-in. red gum facing boards. They are 31 ft. 10¾ in. long over all and 22 ft. 6 in. high. The iron-bark timbers are 18 in. by 12 in., laid one on the other for the lower part of the leaves, but fitted with spacers of varying sizes up to 15 in. for the upper part, which is covered by 6 in. by 2 in. sheathing on both sides. The whole is held together by numerous steel (5 in. by ⅜ in.) straps, some of which are provided with turnbuckles, and with diagonal stays extending from close to the top pivot to the outer toe. The hollow quoins are cast iron. The gates are hung so as to be slightly eccentric to the quoins, giving freedom of movement for the greater part of the swing, and closing up to the quoins as the mitres come together.

The lock gates are operated by spars, ropes and capstans. Each leaf is furnished with two capstans consisting of small tapered drums, from 7½ in. to 9½ in. diameter by 8 in. high, worked by capstan bars 4 ft. 6 in. long. These capstans are placed as shown in Fig. 40. One is connected by a ½-in. wire rope direct to the mitre end of the leaf. The other is also furnished with a wire rope connected with the shore end of a long spar, the outer end of which is coupled to the gate leaf not far from the mitre end. On the gates being opened by winding in on the first set of capstans the ends of the gate spars follow paths shown by dotted curves in Fig. 40, till finally, when the leaves are open they project beyond the walls at right angles. To close the leaves the second lot of capstans are made to haul in the spar rope. The spars in these movements are each supported by horses fitted with rollers. On the shore side four horses are provided at each gate, all of the simple character shown in Figs. 41 and 42. On the river side each spar is carried by two horses of the same type and by a third carried in a triangular frame bracketted out from the back of the wall as shown on the right side of Fig. 40, and in the details, Figs. 45, 46 and 47. In addition to the gate-operating capstans, manœuvring capstans of similar type are provided at each end of the lock on both sides.

(To be continued.)

UNIVERSITY OF BRITISH COLUMBIA.—The construction of the new buildings for the University of British Columbia at Vancouver, has now progressed far enough to permit of making a start in equipping the various laboratories. Dr. H. Vickers, Professor of Electrical Engineering in the University, has prepared a list of the requirements among which are included one 5-ton overhead crane, several material-testing machines, together with pumps, injectors, &c. Dr. Vickers intends to instal wherever possible British made equipment in the laboratories of his Department, and would be glad to hear from any United Kingdom firm interested. United Kingdom firms in a position to supply equipment may obtain further particulars from the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1.

TORRUMBARRY LOCK AND WEIR; MURRAY RIVER.

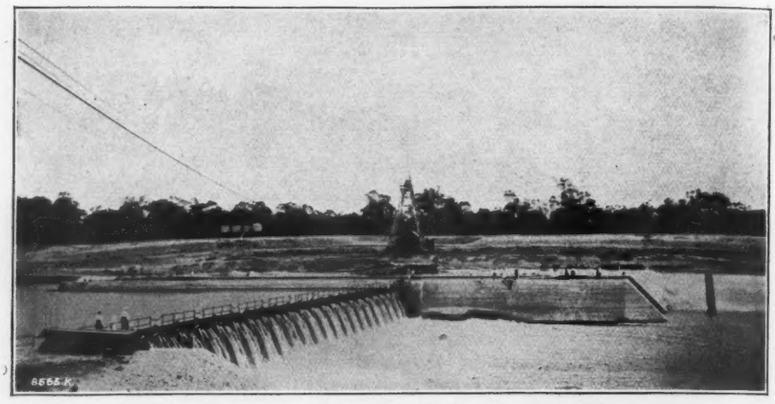


FIG. 50. VIEW FROM EAST BANK.

FIG. 51. VIEW SHOWING RIVER IN FLOOD.

INSTITUTION OF NAVAL ARCHITECTS.

(Concluded from page 446.)

ALTERATIONS TO RULES, &C.

THE first business of the meeting which reassembled on the morning of Friday, April 3, was the election of new members, associate members, associates and students. The chairman, His Grace the Duke of Northumberland, called upon the Secretary to read the names of the candidates in each class, and these were put to the meeting and duly elected.

After the scrutineers for the next annual meeting have been similarly appointed, the meeting proceeded to the consideration of the amendments to the rules governing the election of members, associate members and students. Sir John Biles, invited by the chairman to move the amendment, said the proposed alterations had been circulated to members in printed form, but he would briefly explain their object. The changes, he said, had just been evolved by a Committee of which he was the chairman. Their suggestions had been put before the Council, who had made some changes, which had been approved by the Committee and had been embodied in the alterations before the meeting.

The intention of the Council was to stiffen up the conditions of admission to the Institution, membership of which was regarded as a criterion of ability in naval architecture or marine engineering, and was respected by the public. Although the Institution was founded 65 years ago, no alterations in the conditions for membership had been made until 1899, the rules made at that time being those now in existence. In interpreting these rules, however, the Council had gradually taken a more severe view of the qualifications for membership, steadily making the conditions such that it was necessary for candidates to have higher qualifications than were considered necessary 25 years ago.

Other institutions, he remarked, had made similar changes in their requirements for admission, and he did not think those which it was now proposed to make for the Institution of Naval Architects would render the conditions too severe. They were intended to encourage men to go through a technical college or university course, but if circumstances prevented this, candidates could submit evidence of suitable education and professional training and of 10 years' employment in a position of responsibility in a shipyard or marine engineering works, and of having reached a position of eminence in the profession. This widened the class of persons admitted to full membership, and it was generally intended to embrace those whose competency could not be doubted.

In formally seconding the resolution, Sir Alexander Richardson said Sir John Biles had had unique experience in the training of naval architects and had done splendid work in preparing the new rules, which, if they made entrance more difficult, would bring more honour to membership. The proposed amendments were then put to the meeting by the Chairman and carried unanimously.

TONNAGE LEGISLATION.

The first paper taken was one by Mr. E. W. Blocksidge, entitled "Tonnage Legislation and its Application to the Measurement of Ships." This paper, which was read in abstract by the author, contained in diagrammatic form the results of an investigation as to the effects of alterations in tonnage regulations on the net-register tonnage of ships from the year 1720 to the present time.

showing the maximum change which would occur if a ship were re-measured for tonnage at each period. The calculated effect of these periodical changes in the regulations on the total tonnage of British ships was also shown, so that it was possible to estimate the decrease in net-register tonnage from one period to another for a ship of standard characteristics. From investigations made with a number of cargo steamers of standard dimensions, ranging from 200 ft. to 500 ft. in length, it was shown that net-register tonnage is not now an index of the carrying or earning capacity of a ship. A number of legal cases affecting British tonnage regulations were quoted, and the question of the propelling-power allowance, as a deduction from gross tonnage, was also discussed. The author suggested that the time was ripe for international agreement on the question of tonnage measurement, pointing out that uniformity of regulations and their interpretation would prevent delay and expense to shipowners, since the tonnage inserted on the certificate of registry would then be accepted in all ports and canals for tonnage and port dues, and also for towage and dock charges.

The discussion on this paper was opened by Sir John Biles, who pointed out, in the course of his remarks, that taxation in general was based on the ability to pay, or on the value of the services rendered. The latter, applied to dock services, was measured in terms of the length of quay, the depth and area of water, &c., and dock owners' charges were best based on gross tonnage. The measure of ability to pay, he said, was fairly equal in ships of the same type, although the case might be different with ships of high power. In general, however, ships earned about the same rate of interest, whether they were of high or low speed, and ability to pay was therefore fairly uniform for all classes. It would be simplest, he remarked in conclusion, to base all payments on the gross tonnage.

Mr. John Anderson, the next speaker, said we must look to shipowners for agreement as to any modifications made, and it was evident that some vessels would benefit by more equitable treatment, while others would suffer. Owners of high-powered vessels of fine form found the present regulations satisfactory, while those who owned low-powered ships or intermediate liners and wished to adopt new types of propelling machinery for them, might bear an unduly heavy burden; they were, therefore, desirous of modifications of the law to ensure more equitable treatment. A considerable portion of the present trouble, he said, was caused by the preferential treatment granted to steamers in 1834, and if the allowance for propelling power were entirely eliminated the greatest difficulty would be removed. He did not think the measurement of superstructures would be strongly contested in the case of cargo vessels, as it seemed to be the rule to charge dues on any cargo carried in superstructures, except in the case of home-trade vessels, which were permitted to carry deck cargoes free of charge. A number of papers had been read bearing on the subject, from which, and from the discussions on them, it would be found that there was a general tendency to favour taxation based on services rendered.

Sir Charles Sanders said he was not sure, if a simple method of arriving at tonnage were introduced, that naval architects would be pleased, since the present method enabled them to use considerable ingenuity in design. If, however, the Institution could produce a scheme that would be acceptable internationally it would be doing a great service to mercantile commerce. It was important to arrive at some system which would be equitable between ship and ship, and also satisfy both dockowners and shipowners. It must be remembered, however, that Great Britain had the most to lose if such regulations were not accepted by other countries.

The last speaker in the discussion, Mr. E. F. Spanner, referred to the anomalies and irregularities arising from existing regulations, and expressed the view that the best method to determine tonnage would be to use the simple formula, tonnage $= \frac{L \times B \times \text{Draught}}{\text{Constant}}$, applying this formula to vessels of all classes and types. A notification to port, harbour, and canal authorities that such a basis of tonnage measurement would be put in force in, say, 12 or 18 months' time, would permit new schedules of tonnage dues to be drawn up, so that the change would not cause any serious dislocation. Port schedules would always be varied and complicated, however the tonnage figure were arrived at, but it was better to use simple tonnage rules and confine the complications to the schedules. It must be remembered that revenue was necessary to port and other authorities, and the evasion of charges by some owners did not promote the general good. Such evasion was distasteful to many owners who, however, were forced by economic pressure to take advantage of arrangements of hatches, doors, side openings, &c., the only real value of which was that they cut down the net-register figures, and gave facilities which would not otherwise be allowed.

The author, whose reply was then taken, said it would occupy more time than was available for him to deal adequately with the points raised by the speakers. He agreed with Sir John Biles and Mr. Anderson, and stated that if his paper were read carefully it would be found that he had indicated a policy which perhaps had not been brought out as he had read it to the meeting. Tonnage measurements, he thought, should be based on draught, but as long as there were clever men to make regulations so long would there be clever men to design ships to evade them.

The Design of Intermediate Passenger Vessels.

The next paper on the programme was one entitled "The Influence of Trading Conditions on the Design of Intermediate Passenger Vessels," which was then read by its author, Mr. W. G. Cleghorn. The paper pointed out that the primary quality of a cargo vessel, *i.e.*, deadweight, had little in common with that of a passenger vessel in which was deck area was vital. The design of an intermediate vessel must necessarily involve many compromises. Investigations were made assuming a deck area of 120,000 sq. ft. for the accommodation of passengers and crew, and a service speed of 16 knots on a 3,000-mile voyage, with bunker capacity for the round trip. The breadth was taken as $\frac{L}{10} + 15$ ft. throughout, and the maximum moulded draught as 30 ft., geared-turbine machinery, with oil-fired boilers, being the only method of propulsion considered. Different associated cargo deadweights, up to 14,000 tons, were dealt with, leading to three different types of vessel with accommodation for passengers and crew on four, five and six decks, respectively, and, in addition, a vessel with accommodation on six decks, but with the draught so reduced as to eliminate the cargo deadweight, were investigated. For each type, four different block coefficients were taken, so that the investigations covered 16 different vessels in all. The earning power of each ship was calculated at various cargo rates and passenger rates, the results being given in tabular form. Over a considerable variation in rates, the best all-round vessel appeared to be one of about 550 ft. length between perpendiculars, carrying passengers on the main, upper, shelter, bridge and promenade decks, in addition to about 8,300 tons of cargo, this conclusion being based, of course, on the particular assumptions made.

The first speaker in the discussion on this paper was Dr. P. A. Hillhouse, who remarked that it was usual before building a new ship to carry out an investigation of its probable earning powers, the procedure generally being based on some vessel in service and the data modified in directions likely to lead to more economical results. The conclusions would naturally depend upon the assumptions made, but generally, with a given passenger rate, a decrease in the cargo rate led to a finer ship with the passenger accommodation on more decks. For a given cargo rate, on the other hand, a decrease in passenger rates led to a larger, fuller ship with fewer decks. A shipowner was thus called upon to act as a prophet, but it was comforting to note that, according to the author, there was not much difference between the best and second-best ships. He noticed that the author had assumed a fixed price for fuel and, with regard to the cargo, had assumed that the necessary amount would always be available, which might not be the case. In conclusion, he remarked that the author's investigations were very illuminating on the assumptions made, but in any actual case, he thought, many other assumptions would have to be considered before a definite conclusion could be arrived at.

Mr. J. Anderson, after congratulating the author on his work, said he was surprised to find no reference in the text to the time-efficiency element for each class of vessel. If it had been assumed that the vessels were working on a fixed time schedule, the conclusions would probably hold good, but, if the turn round were made as quickly as it could be in each case, the vessels of finer form, carrying a maximum number of passengers with less cargo, would probably appear in a much more favourable light. He wished to point out that technical considerations in connection with large passenger ships were complicated by the great variations in trading conditions. Very few passengers were carried in certain seasons of the year when a considerable space was available for cargo, while at other seasons all available spaces were required for passengers and no cargo was available. What would be the author's recommendations in those circumstances? He also considered that the author had not been quite fair as to the dimensions and first cost of non-cargo-carrying vessels; further analysis, he thought, would make the latter appear to better advantage.

The last speaker on this paper, Mr. Thomas Graham, said he thought the author had made a serious error in paying too much attention to deadweight and too little to capacity. Many post-war ships, he said, were too full, their designers having been guided by deadweight instead of by capacity. Light service draught was the best basis for design, and this called for finer ships than those considered by Mr. Cleghorn. For most conditions, an intermediate ship with a block coefficient of 0·65 was the best. In general, he thought there was a tendency to pay more attention to maximum conditions than to ordinary working conditions, and, in conclusion, he expressed the hope that the author would consider the problem of reconciling deadweight and capacity.

In the course of his reply, which was then taken, Mr. Cleghorn stated, in connection with Dr. Hillhouse's remarks, that the cargo rate taken was that obtainable over the whole year. In answer to Mr. Anderson, he explained that the percentage earnings shown in the table were for a fixed time schedule, but an alteration could be made in the figures to suit another schedule. Any saving due to a quick turn round affected overhead charges, which were not allowed for in the table at all and would have to be deducted. In reply to Mr. Graham he said he had in mind the necessity for providing capacity for cargo, but found it complicated and difficult to make the necessary calculations. It was difficult to get a criterion of the value of capacity, which he agreed was a very important matter. He was of opinion that the block coefficient of 0·65 given by Mr. Graham as a good average value for vessels of the intermediate class, was in close agreement, with the figure 0·655, which was the average value of the block coefficients for the class including the best all-round vessel referred to in the paper.

Stability and Seaworthiness.

Mr. C. Frodsham Holt was then called upon by the chairman to read a paper bearing the title of "Stability and Seaworthiness." This he gave in abstract. The paper is reproduced in abridged form on page 496 of this issue, so that it is unnecessary to refer here to the nature of its contents.

The first speaker in the discussion which followed the reading of the paper was Professor T. B. Abell, who referred to the effect on stability of loose cargoes such as small coal. The master of a ship, he said, was responsible for her stability and seaworthiness, and it was desirable to assist him, as far as possible, to realise the

condition of his ship. In devising his instrument, the author had reviewed all the factors affecting stability and had prepared a table for use with the instrument. The device, Professor Abell presumed, was a long-period pendulum, and he had no doubt that it would accurately record the period of rolling in harbour water. What the master wished to know was the least permissible metacentric height and what he had actually got at any time. This could only be deduced in harbour by some form of instrument, and that devised by the author appeared to meet the requirements. The instrument could be more readily employed than the method of inclining the ship, which, however, was more easily understood by masters than the dynamic method. The matter, he concluded, was of considerable importance, as ships were being lost owing to lack of knowledge as to the behaviour of cargo.

Dr. A. M. Robb, who followed, said the most important feature of the paper was that it was the first in which an attempt had been made to develop a comprehensive standard of stability. No one appeared to know what that standard should be. He would suggest that a committee should be appointed to see whether agreement could be reached. He, therefore, wished formally to move that such a committee be appointed. The Chairman explained, however, that such a matter must be referred to the Council and to this Dr. Robb agreed.

A contribution to the discussion prepared by Mr. W. J. Berry was then read by Mr. Lloyd Woollard. In this, it was pointed out that much of the material in the paper could not be disputed. When, however, it was attempted to compute the heel in a gale or the extent of rolling in a violent seaway, difficulties arose. The methods proposed in the paper were of value when used for comparing ships of similar types, but without such comparison and without applying the methods to ships of which the seagoing qualities had been proved by experience, it would be unsafe to formulate any theories. The author did not appear to have applied a check of this character to his work, but if he would do so, including a few ships of doubtful stability as well as a large number of vessels the seagoing qualities of which had been proved by experience, a better opinion could be formed of the value of his methods. The figures of 55 lb. per square foot for the wind pressure, used in the paper for estimating the heel or roll of a ship under a sudden gust, Mr. Berry regarded as excessive and suggested that one-fourth of that figure would be nearer the truth in the case of a large ship. He did not, however, wish to underestimate the value of theoretical investigations such as those made in connection with the paper, but to point out that all such work was of greater value when it had been fully tested. He hoped that Mr. Holt would be able to do this, and that he would communicate the results to the Institution.

The last speaker, Mr. E. F. Spanner, said he was inclined to challenge the author's statement that positive initial stability, at all times when at sea, was a first essential to seaworthiness. He agreed that it was desirable for a ship to have positive metacentric height in the upright condition, but a great difference existed between that and the author's attitude in condemning as unseaworthy any vessel having a negative G.M. Many vessels arrived in the Thames in a decidedly unstable condition, having been unstable throughout the greater part of their voyage, but such vessels could not be regarded as unseaworthy. They had a considerable reserve of buoyancy and, on being inclined further, would develop very satisfactory righting couples. Initial stability was only one of the factors affecting seaworthiness, freeboard and the character of the weatherdeck closing arrangements being, in many cases, of far greater importance. The question of determining the safe effective range of heel was also of great difficulty and the author's suggestion that it was limited by the angle at which certain closing appliances entered the water and became liable to broaching under the direct blows of storm waves, he regarded as being unduly optimistic. In heavy wind and weather, the parts of the hatches and other parts which suffered most were those on the weather side and not those on the lee side. It was quite possible that of two otherwise similar vessels in similar weather conditions, one having positive and the other slight negative stability, the latter would survive and the other founder since the tender vessel would heel further from the wind, and thereby shelter her vulnerable weatherdeck openings; in the stiffer ship, on the other hand, the openings would have to withstand continued battering from heavy broadside seas breaking over the deck. Mr. Spanner, after expressing his full appreciation of the care and ability displayed by the author in obtaining stability data from observations of the rolling period, concluded by remarking that he thought the older and more straightforward methods would be difficult to oust. He looked forward with interest, however, to a further report after extended practical experience with the instrument.

The author, who then replied to the discussion, first remarked that, owing to the limited time available, he would not go into detail but would reply more fully in writing. In answer to Professor Abell, he said it was correct that his instrument was a long-period pendulum although not of the ordinary kind. It employed a casing filled with water and had a period of about one minute, which was much longer than that of the ship. As Professor Abell had stated, it was the least metacentric height which was of most importance to the master, and also to the owner. A ship with the metacentre as low as possible was safer at sea and also permitted greater freedom in the stowage of cargo. Inclining experiments were a good alternative to his suggested method of determining stability, but they interfered with work on the ship and many masters had not sufficient technical knowledge to carry them out. He agreed that coal was a dangerous cargo if a ship had considerable stability. If the stability was too low, however, bad weather might cause the cargo to shift and many ships were in greater danger of loss for this reason than was generally supposed. To the speakers who had inquired about the application of his standard to various ships, he replied that he had done so and had also applied it to a ship known to have been lost at sea. In this case it had been thought that the metacentric height was insufficient, and it had, in fact, been found to be less than required by his proposed standard. He did not agree with Mr. Spanner's views as to the safety of a ship at sea with negative metacentric height. A curve given in his paper showed that a ship in that condition would be safe theoretically, but it would not be safe from a practical point of view. Consideration must be given to the possibility of the cargo shifting, the contents of the bunkers, the action of the helm and the general unmanageability of the ship. It was desirable to have as low a metacentric height as possible without going below a lower limit.

This concluded the business for the morning, and after the chairman had thanked Mr. Holt for his paper the meeting was adjourned until the afternoon.

THE CORRUGATED SHIP.

At the Friday afternoon meeting the Duke of Northumberland, President, occupied the chair and called upon Dr. E. V. Telfer to present the paper on "The Propulsive Performance of the Corrugated Ship" contributed by Mr. A. H. Haver and himself. In this it was stated that after Mr. Haver had invented the turret ship he was approached to investigate the possibility of its further development. After some experimental work, it was decided that a reduction in propelling power of the order of 8 per cent. might be expected from the use of a single groove along each side of a vessel. It was realised that this reduction was obtained at the expense of displacement, but the amount of power reduction was recognised as too great to be explained merely from the standpoint of reduced displacement. It appeared probable that forming a groove by the addition of two adjacent bulges along a ship's sides might not only increase the displacement, but also reduce the horse-power. Further experiments were made, and it was found that, by suitably shaping and disposing these corrugations, a reduction of power of about 16 per cent. was apparently realisable in vessels of full merchant-ship form. Shortly afterwards the Monitoria, owned by the Ericsson Shipping Company, was built by Messrs. Osbourne, Graham, of Sunderland, and was proved to be satisfactory. Since then 20 vessels had been built, all having block coefficients of the order of 0·78, and it was said that all had done what was predicted of them. The preponderating resistances met with in the models of merchantmen were those which did not follow the Froude law, but followed the Reynolds or Rayleigh law. The thrust performances of plain and corrugated ships which had speeds of less than 11 knots were the same, but for higher speeds the corrugated ships had the advantage. At 12 knots this amounted to 6·3 per cent., and at 13 knots at 5·9 per cent.

Mr. W. J. Berry, Director of Naval Construction, in opening the discussion, said the authors quoted the results obtained by Kempf, showing an increased frictional coefficient with decrease in radius of immersed surface. They deduced from this that the model with its proportionately reduced radius of curvature had a relatively greater frictional resistance, and hence would hide the advantages resulting from the corrugations. Applying this same reasoning to ships, as small radii of curvature were bad, then flat surface would prove better than curved ones, and hence the plain ship would be better than the corrugated one as regards skin friction, as the authors stated. Despite this, the total resistance of the corrugated ship was inferred to be less than that of the plain ship. Therefore, the corrugated ship must have a diminished eddy and wave-making resistance. There were, however, reasons for supposing that the eddy resistance was greater in the corrugated ship than in the plain one. That meant that the wave-making action must be less. There did not appear to be any fundamental difference in the wave profiles to justify such a supposition. He was therefore disinclined to accept the authors' reasoning. Whatever small differences were observable in the results obtained in model tests of the two forms, corrugated and plain, might be due to differences in the experimental conditions. On these it seemed that the supposed superiority of the corrugated ship rested.

In the paper the test results obtained with the S.S. Azul were given, but showed quite different figures from those obtained with a sister ship, the Rio Blanco, at the tests of which an Admiralty overseer was present. This vessel, the Rio Blanco, had a displacement of 9,985 tons when tested on the Hartley mile. The results obtained were :—

Speed.	Indicated Horse-Power.	Revolutions per Minute.
11·38	2,601	73·6
9·99	1,807	66·1
9·23	1,461	59·6
8·30	1,149	54·6

From these results it must be concluded that the Azul was a half knot better than the Rio Blanco, but as far as one was aware there was no independent observer of the speed of the Azul. An attempt was made to explain the results of the Rio Blanco tests by the rough sea, but the conditions at the time were not in any way unusual and would not have stopped an Admiralty trial from being made. Moreover, it was one of the advantages claimed for the corrugated ship that it had a better propulsive performance in all weathers at sea, so it must appear that the weather could not be blamed.

The superiority of the corrugated ship required a great deal more demonstration if the claims made for it were to be substantiated. If a ship had an excessive block coefficient the stream lines would not be expected to be very good, and in such a case corrugations might give a benefit by inducing a better run for the stream lines and also an improved flow of water to the propeller. Trials made with two models, the one corrugated and the other plain, would be of greater utility than any amount of theoretical considerations, but the authors seemed to be distrustful of the ordinary law of comparison for their particular design of ship. In Admiralty vessels, which were of fine block coefficient, the experience of many years had shown that any departure from ordinary ship-shape form in the section, always involved greater resistance to propulsion.

Mr. G. S. Baker stated that in the paper the

authors gave the results of two model tests made in a German tank. Based upon these results the authors claimed to demonstrate that at the same speed, 12 knots, the corrugated ship would require an indicated power of 2,670, while the plain-sided ship needed 3,050 h.p. Tests at the National Tank showed that the power required for corrugated ships exceeded that for the plain type by a very small amount and, consequently, there was little or nothing to be gained by their use. To obtain a reason for departing from the ordinary model data the authors had shown great ingenuity, the substance of which was that the skin friction of a corrugation on a 16-ft. to 18-ft. model was high by 3 per cent. This was accounted for by a number of assumptions, involving Kempf's pipe experiments and the Prandtl boundary theory. He did not think that they could not believe in the existence of any 3 per cent. gain. If it were obtainable, it would be possible to detect it and no data obtained at the National Tank showed it. Even were this so, it was difficult to believe that a feature which made a test with an 18-ft. model 3 per cent. worse in results, would make a ship 16 per cent. better. Were the theory sound, what became of the much greater additional resistance of the corrugated form, which it involved in the small scale models used by Mr. Haver was a subject worthy of consideration.

Leaving the theoretical aspect, Mr. Baker proceeded to give the figures obtained from the logs for vessels which were practically sister ships. For the purpose in view he took 12 similar voyages obtaining the following results:—

	Plain.	Corrugated.
Total distance travelled in nautical miles	89,040	86,130
Number of days at sea	430	475
Average speed .. .. .. knots	8·73	7·77
Average indicated horse-power	756	741
Coal per day .. .. .. tons	14·7	13·5
Deadweight .. .. .. tons	2,852	2,810
Mean revolutions per minute / Mean speed in knots	7·5	7·5
Coal per day per 1,000 tons deadweight carried / V^3	0·0078	0·0102

It would be seen that the plain-sided ship was in fact a little better than the corrugated one, and that she had carried a given cargo with practically the same amount of coal consumed in a somewhat shorter time. Her average speed had been greater and the coal per day was more. Dealing with these results analytically, it would be found that there was no effect apparent due to the corrugations. The relationship of the revolutions of the engines to the mean speed in knots showed that there was no particular propeller effect observable.

Mr. George Humphrys said that as a consulting marine engineer he advocated the corrugated system of ship construction to his clients. He was astounded that the figures given by Mr. Baker should be used to condemn the principle of construction when they showed that the coal used per day was 14·7 tons for a plain ship and 13·7 tons for a corrugated one. In his experience the results obtained with corrugated ships bore out the contentions made by the authors of the paper. In reference to Mr. Berry's comments on the trials of the Rio Blanco he said that they had to put into the Tyne, to land the visiting party, because of the very heavy sea. Naturally the results of tests under such conditions were not so good. Mr. Berry here interposed that he was informed the conditions were not so bad as to prevent Admiralty test work.

Dr. Kempf stated that he could not agree that application of his work on pipes could be made, in dealing with the effects of corrugations on ship resistances.

Admiral Taylor said that they must have more information regarding the results obtained with corrugated ships. At 8 knots to 10 knots the plain ship showed less resistance. The thrusts of the full-sized ships were practically the same. For torque there was a difference in favour of the corrugated ship which required some sort of explanation. The difference in the draught aft might give a possible solution. Corrugations might be corrective because they offered excess resistance due to the grooves.

Professor T. B. Abell said if there was a difference in favour of the corrugated ship it would not be necessary to talk of Rayleigh's law being modified. Tests might have been conducted to determine the characteristics of a corrugated plate. Shipowners and marine engineers might show that they could carry more deadweight on the same quantity of steel if corrugations were used, but so far, apart from that, there was not sufficient evidence to warrant the construction.

Mr. W. G. A. Perring discussed the way in which the corrugations might affect a ship. These generally would increase the resistance, but it was possible that there was some recovery aft due to the modification of the boundary layer.

Mr. John Tutin intimated that it would be expected that any advantage in fitting corrugations would be chiefly due to a possible reduction in wave resistance. It was impossible to say from the paper whether that was so or not, although it was stated that the stern wave was more pronounced than with a plain ship. The draught of the corrugated ship was reduced to obtain the same displacement. In other words a layer of displacement at the maximum angles of entrance and run had been redistributed below the waterline for the corrugated ship. A reduction of resistance might be due to that effect and not to any virtue in the corrugations themselves. Regarding the paper as a whole it would appear that the reduction in resistance, which was claimed, could hardly be said to have been established.

Mr. M. P. Payne thought that if corrugations were advantageous it should be worth while to extend their use to the bottom of the ship, when the percentage gain should be of ample magnitude to be beyond dispute. He had too much admiration for Dr. Gebers' work to question the accuracy of his results, but it was found at Haslar to be extremely difficult to determine with accuracy the augmentation of resistance, when the screws were working. It was difficult to imagine how the lower corrugations, which ended over 50 ft. from the stern, could have any appreciable effect on the thrust deduction.

Mr. Spanner referred to the fact that marine engineers were perfectly satisfied with the improved results obtained with corrugated ships and were building more. Corrugations might produce a better flow to the propeller than was even the case with the contra-propeller under the conditions at sea. The advantage of the system of construction, though it might be difficult to understand, was a perfectly definite one.

Mr. A. H. Haver, in reply, said he did not know what ships were referred to by Mr. Baker in the table of log results he submitted. In actual ships they had always found corrugations advantageous. After testing a plain model to get a speed and power curve, the addition of corrugations did not always give good results, through the corrugations not synchronising. But whenever they got good results with the model they were realised in the actual ship. It was not to be expected that the Rio Blanco speed-power curve would be repeated in a 16 ft. sea. The use of corrugations reduced rolling. Better results were obtained with bulges than grooves.

Dr. Telfer also replied, and stated that the modification caused by introducing corrugations, though small, was of great significance. There was no doubt in his mind that the claims made for the system were reasonable. Dr. Kempf had told him of a clear improvement of 3 per cent. obtained in tests with a corrugated ship model. Mr. Baker might find similar results if he varied the position of the corrugations. The reason the torques were different for a plain and a corrugated ship was the change in the nature of flow. It was not a case of diminution of skin friction. The positions of the corrugations, necessary to obtain the requisite change of flow, were on the two sides of a vessel and no improvement could be anticipated from their use on the bottom of the hull.

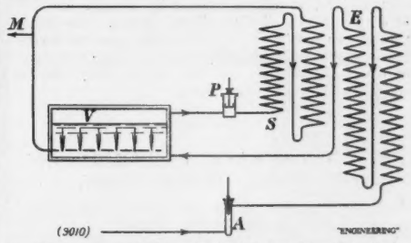
The Duke of Northumberland, in proposing a vote of thanks to the authors, said that although the subject had proved very controversial, they had made out a good case for further investigation.

The meetings of the Institution of Naval Architects were then brought to a close by the expression of the indebtedness of the members to the Duke of Northumberland as their President by Sir Archibald Denny, and to the Secretary, Mr. R. W. Dana, and staff of the Institution, by Mr. W. J. Luke.

THE LÖFFLER SYSTEM OF HIGH-PRESSURE STEAM GENERATION.

A NOVEL system of high-pressure steam generation has been worked out by Professor Löffler, of the Technical High School, Charlottenburg, and is being developed by the Wiener Lokomotivfabrik at Floridsdorf, near Vienna. An experimental 100-kw. plant working with steam at pressures of 100 atmospheres and more, has been in operation since December. The 900-kw. power station of the works is being rebuilt with the addition of a high-pressure plant on this system; a 2,000-h.p. express locomotive for steam pressures of 120 atmospheres is also under construction, and the 18,000-kw., high-pressure turbine plant of the collieries of the Witkowitz steel works is being modified on the Löffler system. We are indebted to Professor A. Riedler, late of Charlottenburg, now of Vienna, who has taken part in the trials of the experimental plant, for our information as to this interesting departure. Further particulars will soon be available, and we reserve any comments.

The characteristic feature of the Löffler system lies in the fact that the whole of the transfer of heat from fuel to steam takes place in the feed heater and in the superheater, so that the boiler is not exposed to the fire. Evaporation in the boiler is effected by superheated steam bled from the main steam range. The pressure in this is higher than the boiler pressure, and



the steam evaporated in the boiler has therefore to be compressed into the superheater by a special pump. The general scheme of the apparatus is shown in the figure above. The feed pump A sends the water through the feedheater E into the lower portion of the boiler or vaporiser V. In starting up such a plant, steam is drawn from any convenient steam main, or if this be unavailable from a small auxiliary boiler, and forced by the pump P into the superheaters. From the superheater it is passed to the boiler, and escapes up through the water there, as indicated. Ultimately fresh steam is generated here, which is also pumped through the superheater back into the boiler, thus generating more steam, which goes through the same cycle. When the pressure and temperature in the boiler have reached the required limits, the supply of auxiliary steam is discontinuity, and evaporation proceeds solely with the steam bled from the superheater.

The advantage claimed for the process is that the steam generation and superheating are interdependent, through taking place in separate apparatus, and that modifications of the old spacious and useful Cornwall boiler may be utilised for working with steam at really high pressures of 100 atmospheres and above, at which the superior economy of superheated steam becomes realisable, instead of the modern complicated tubular boilers of limited capacity. Circulation in the tubes of the latter depends upon density differences in the descending current of cold water and the ascending current of hot water. The circulation is impeded by the liberation of steam bubbles and by the deposition of scale, which introduces the dangers of local overheating. In the Löffler system scale can only be deposited in the vaporiser, where it does little harm. The internal incrustation, though not desirable, facilitates the heat insulation of the vaporiser, which however, is, of course, carefully lagged. The whole vaporiser is under high pressure, of course; but the heating is fairly uniform, and the local thermal stresses will be reduced in the absence of external heating.

The Wiener Lokomotivfabrik quite recognise that steam generators and engines to work at pressures of 100 atmospheres cannot be designed and constructed on the lines of the old-established practice, even if that practice had shaken off the shackles of tradition. New problems have to be solved, and all old strength data, expansion coefficients and designs can only be accepted if confirmed by new experience gained, not in the laboratory, but under

actual working conditions. To gain experience in these matters a piston pump was adopted for maintaining the circulation. A small centrifugal pump could perform what a relatively large piston pump is doing. But the piston pump requires stuffing boxes, piston, packings and lubrication just as the high-pressure steam engines which the steam is intended to drive, and the pump used has proved equal to its work. The actual duty of the pump is not high, as it has only to overcome a differential pressure; but it works under high pressure all the time, and is, like the steam pipes, lagged with glass wool and plaster, while its speed is adjustable within wide limits up to 230 r.p.m. No serious trouble has arisen during the trials which have been made. Steam is superheated to 450 to 500 deg. C. (840 to 930 deg. F.), and sometimes to 600 deg. C. (1,110 deg. F.); in one instance a leakage occurred when the temperature was lowered from 600 down to 450 deg. C., but that trouble was remedied. Most of the trials were not prolonged for more than six or nine hours. Starting with cold water, full pressure was obtained in about 1½ hours, auxiliary steam being required for half that time. In order to ensure comparable test results, oil fuel was used. The engineer in charge of the trial had all the electric indicators of the various measuring and recording instruments, mounted on a board placed on his table. He could thus see at a glance the oil level and oil consumption, the water level in the boiler, the steam pressures before and after the superheater, the steam consumption, the temperature at different points and the percentages of carbon dioxide and carbon monoxide in the flue gases. Temperatures were determined with the aid of thermo-couples and by taking measurements of the pipe expansion. The two modes of measurements have been found to agree. The special instruments used, comprising steam meters, were constructed by Messrs. Siemens and Halske to the design of Dr. Löffler. The boiler or vaporiser was built by the Press und Walzwerk Düsseldorf-Reisholz, likewise to Dr. Löffler's design; the drum is pressed out of special steel and is provided with screwed-in covers.

EFFECT OF BACK PRESSURE ON OIL WELL PRODUCTION.

FOR the movement of petroleum underground towards a well a difference of pressure is requisite between the well and the outlying parts of a natural oil reservoir. As the rock pressure on the oil-bearing formation declines, the pressure at the well must be lowered in anticipation. In order to maintain the differential pressure in wells of very small initial gas pressure, or when the pressure has become low, wells have been put under a vacuum, when they seemed to require stimulation. This procedure is costly and only applicable to small wells. Instead of allowing the production to diminish or cease owing to want of pressure, though there may still be oil underground, it may be better to minimise the loss of gas and gas pressure so as to ensure a more prolonged flow of oil. Experiments in this direction have been made by T. E. Swigart and C. R. Bopp, of the United States Bureau of Mines (Technical Paper 322), to ascertain whether the ultimate oil recovery could be raised by regulating the pressure.

The oil at the bottom of a well is said to be under "the rock pressure or closed-in pressure." This is the maximum pressure at the casing head when a well has been shut off for some time. It is the sum of the so-called "back pressure" and of the hydraulic pressure due to the column of oil or water in the well. The back pressure is the indicated gauge pressure at the casing head of the well. The pressure regulation in these experiments was effected by keeping the casing head closed at night in the off-hours and blowing off some of the gas during the pumping time. The greatest ultimate oil recovery, it is found, will be obtained when the oil carries away the minimum amount of gas. The higher the back pressure, the lower the daily gas production, and fairly high back pressures can be held on many pumping wells without cutting down their oil production. One of the two wells experimented with was an isolated well. Allowing gas to escape only through the lead line, the daily oil production was decreased by 7 per cent. and the gas liberated by two-thirds. These features promised an increase in the ultimate recovery of oil. The other well was offset on three sides by wells producing at atmospheric pressure and proved sensitive to back pressure; with back pressures of 20 lb. and 30 lb. (when the potential rock pressure was 50 lb.), the daily oil production was reduced by 13 and 37 per cent. Some of the unproduced oil no doubt found its way to the neighbouring wells. Stopcocking—the term used to denote keeping the well closed in and only allowing the gas to flow when oil is being produced—raised the daily oil production over pumping rates at atmospheric pressure in both cases; but the relations were not simple. Yet it would appear that stopcocking may in general be of advantage in increasing the ultimate recovery, though at a slight reduction of the daily rate of output. It would, however, be inadvisable when the conditions involved would send oil over to neighbouring wells. For that and other reasons a production agreement between neighbouring companies would be desirable; such co-operative agreements, often urged, are now actually in force, for instance, in some Mexican fields.

PROFILE-PLOTTING MACHINE.

THE irrigation canals of Egypt, as also those in other countries, are subject to deposits of silt which require periodical removal. It is necessary, accordingly, to take systematic soundings at regular intervals over hundreds of miles of canals, the instruments used for this purpose being the surveyor's level and staff, or sounding apparatus for plumbing the water depth. A very great number of readings are obtained from a single station, and the work of reducing and plotting the field-book entries is often very tedious. Two engineers engaged on this work, Messrs. E. Holland and R. G. Collingwood, came to the conclusion that under the special conditions cited, a great saving of time would be effected if this work could be effected mechanically, and they devised, accordingly, the machine represented in Figs. 1 and 2 above. This machine, after exhaustive and successful tests in actual service, is now being manufactured and marketed by Messrs. Cooke, Troughton and Simms, Limited, of 3 and 5, Broadway, Westminster. Several are now in use by the Egyptian Government, who intend employing them throughout the Irrigation Department.

As shown, the machine consists essentially of a graduated sleeve which slides with easy friction on a cylinder mounted above a table over which travels the profile-paper. Assuming everything is in adjustment, a matter which will be discussed later, the profile is plotted in the following way:—The profile-paper is advanced a distance equal in scale to the distance between the staff and the level. The hand wheel to be seen on the left of Fig. 1 is then rotated until the index shown over the graduated sleeve comes to a graduation on that sleeve, equal to the level reading as taken directly from the field book. The lever visible to the extreme right of Fig. 1 is then depressed, with the result that a pricker pierces the paper at the proper level, and simultaneously a figure printer, by the agency of a typewriter ribbon, prints on the margin of the paper, opposite the plotted part, the *reduced* level of the latter. This done, the paper is advanced to correspond with the distance of the next entry in the field book, the index is again adjusted to the corresponding level reading, and a second point plotted. This operation is repeated until every observation taken from the given station point has been plotted. The plotted points are, of course, connected up in the usual way by drawing a curve through them. Special note should be made that every entry plotted is taken directly from the field-book without reduction of any kind. As shown

PROFILE PLOTTING MACHINE.

MESSRS. COOKE, TROUGHTON AND SIMMS, LIMITED, LONDON.

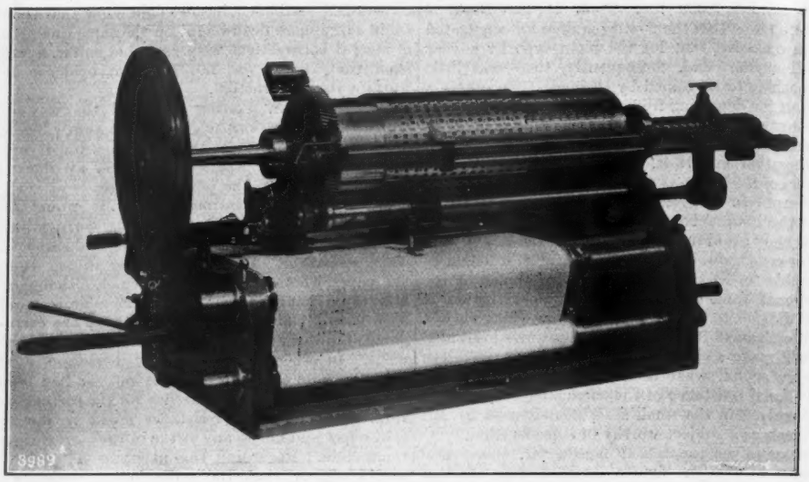


FIG. 1.

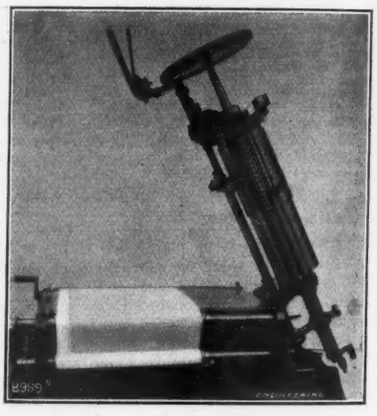


FIG. 2.

in Fig. 2, the cylinder can be swung up from the paper, so that the latter can be examined or removed. In this position the weight of the cylinder and its framework is balanced by a spring provided for the purpose.

When the level is removed to a new station, certain adjustments are required before the work of plotting can be resumed. It will be seen that the cylinder on which the sleeve above mentioned is mounted is also graduated helically. These graduations correspond to different altitudes of the axis of the level telescope. In adjusting the instrument for plotting readings taken from a new station, the sleeve is moved over the cylinder until its zero is aligned with the graduation on the cylinder which corresponds to the altitude of the line of sight. The knurled head shown above the screw on the right of the instrument is then released, an operation which unclamps the screw and permits of its being rotated by means of a handle, best seen to the right of Fig. 2. On the left-hand side of the cylinder a spur wheel is shown. This is in gear with the figure printer already mentioned, and it also operates the counter shown above the wheel in Fig. 1. To proceed with the adjustment, the cylinder is next rotated until this counter reads the height of the line of sight; and as this counter and the figure printer are geared together, the latter is also set to the same figure. The screw is then rotated by its handle until the index is brought to the zero-mark on the sleeve. The position of the pricker is next adjusted by a knurled head provided for the purpose. This accomplished, the screw is again secured against rotation by tightening the clamping head, and, this done, the plot can be proceeded with exactly as before.

The screw, it will be noted, passes through a nut in the end of the cylinder, so that when the latter is

VACUUM FILLING MACHINES FOR LIQUIDS AND POWDERS.

CONSTRUCTED BY THE ALBRO FILLERS AND ENGINEERING COMPANY, LIMITED, ENGINEERS, LONDON.

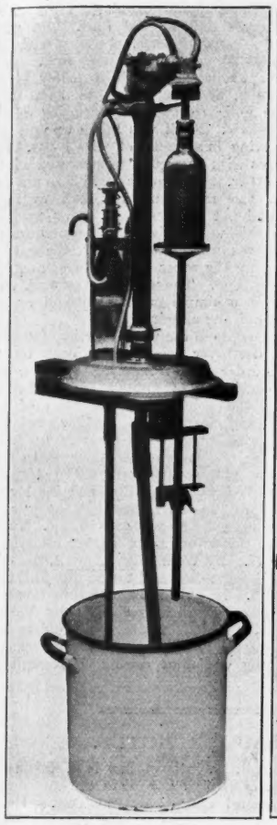


Fig. 1.

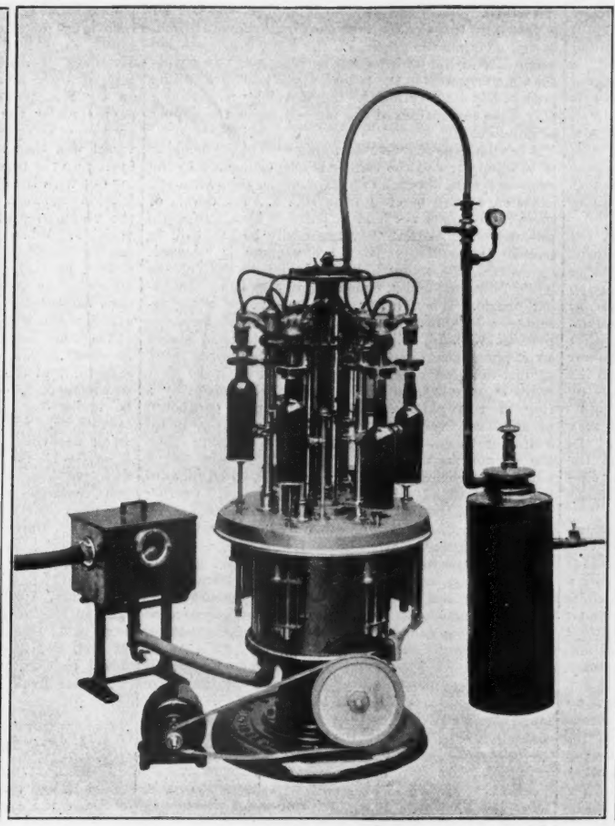


Fig. 2.

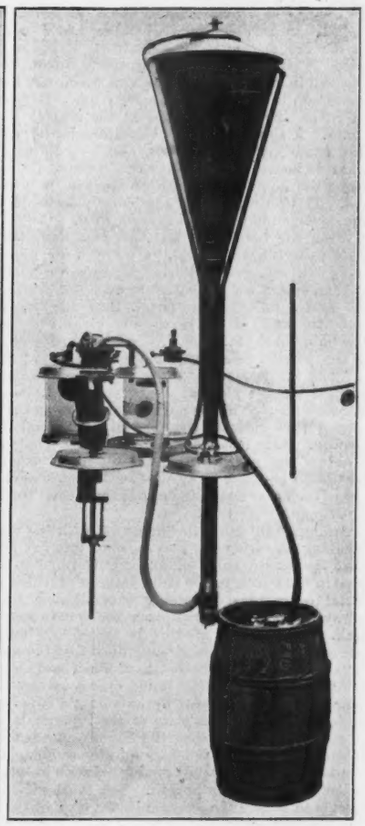


Fig. 3.

rotated and the screw clamped, it can only move in or out, according to the direction of motion of the cylinder. In this motion it carries with it the index and the pricker, to which it is coupled by the sliding rods shown. The pitch of the thread is, of course, the same as that of the graduated helices on the cylinder and sleeve.

Various minor adjustments are provided, and it is, of course, obvious that the instrument can be used for any kind of plotting with rectangular co-ordinates. In the particular class of work for which it was designed the time required to complete a plot is found to be less than one-fourth that formerly necessary.

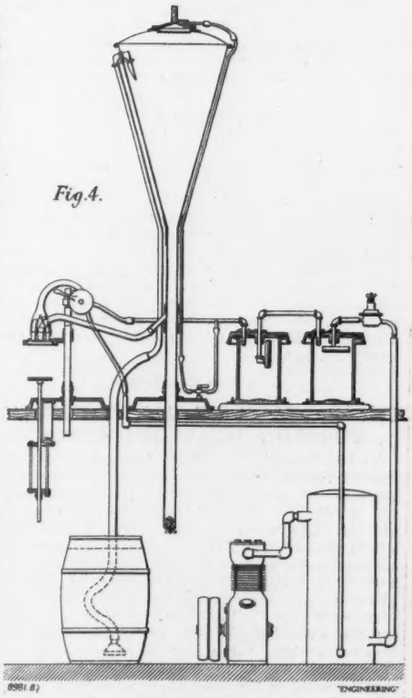
It may be noted in conclusion that it is easy to put a second set of soundings over a first set. This is often convenient in showing on a single sheet, either the accumulation of silt between successive traverses, or the quantity of material removed by dredging.

VACUUM FILLING MACHINES FOR LIQUIDS AND POWDERS.

The fact that an enormous variety of liquid and semi-liquid preparations are retailed in glass bottles, jars, tins and other comparatively small receptacles, has given rise to a considerable demand for appliances to fill such containers rapidly, accurately and without waste. The machines used for the purpose supply the fluid under pressure, by gravity and by vacuum, and each type has particular applications for which it is best suited. The vacuum type, for instance, is not suitable for filling aerated beverages, since the dissolved gases would be, to some extent, withdrawn by the application of the vacuum to the liquid, but for other purposes vacuum filling machines have many advantages.

Two machines of this type, as made by the Albro Fillers and Engineering Company, Limited, 34, Holloway-road, London, N.7, under the patents of Mr. H. F. Broadhurst, are illustrated in Figs. 1 and 2 on this page. These machines, which will handle any liquid from light spirits to heavy creams, sauces, &c., are particularly useful for thick sticky liquids, such as stains and varnishes, as well as for costly liquids, such as perfumes and extracts, any loss of which, due to dripping and leakage, would form a serious item in the cost of production. It will be obvious from the following descriptions, that the bottles, or other receptacles used, are filled to the same level, irrespective of any irregularities in their shape or size, and that a leaky bottle cannot be filled at all, so that this source of loss is avoided. Moreover, the bottles remain quite clean externally after the filling operation. This is a matter of considerable importance when handling sticky liquids or oils, since the presence of the latter on the bottle renders it difficult to apply the gummed labels generally employed to indicate the nature of the contents.

Fig. 4.



The machine, in its simplest form, is illustrated by the photograph reproduced in Fig. 1. This represents the single-head type of machine, which is intended to be mounted on a bench, below the latter being placed a barrel or other receptacle containing the liquid to be filled. The filling head and nozzle are mounted on a vertical tubular stem, which, in turn, is attached to a base plate, in the form of an inverted pan, fixed on to the bench. A pipe dipping into the receptacle below the bench is connected to the tubular stem, as shown, and thus to the filling head. The bottle to be filled is placed on a pneumatically-operated elevating table, the height of which can be adjusted to suit bottles of different lengths, and, when this has been done, the operator turns a plate valve on the side of the filling head to connect the pneumatic cylinder of the table with the vacuum pipe. The vacuum, which is produced by a small reciprocating pump or steam ejector, causes the table to rise so that the filling nozzle enters the neck of the bottle, an air-tight joint being formed between the lower surface of the filling head and the mouth of the bottle, by means of a washer of special soft rubber. The nozzle consists of three tubes, usually made of silver, one, through which the liquid is supplied, being about $\frac{1}{2}$ in. in diameter, and another, about $\frac{1}{4}$ in. in diameter, through which the vacuum is applied. The third tube, which is rather smaller, is for a purpose which will be explained later. All three tubes terminate in the same plane.

The movement of the plate valve, above referred to,

puts the vacuum pipe of the nozzle into communication with the main vacuum pipe, so that the air in the bottle is exhausted and the liquid, which is consequently drawn up from the receptacle under the bench, enters the bottle through the large central tube in the nozzle. In this way the bottle is filled to the level of the lower end of the nozzle, but when this level is reached any further liquid which may enter is drawn up the vacuum pipe. The quantity of liquid which leaves in this way is comparatively small, and is collected in an interceptor through which the vacuum connection to the nozzle is made; the interceptor is shown on the left-hand side of the central stem in Fig. 1. A simple form of vacuum-reducing valve is also fitted on the interceptor, and by adjusting this, so as to increase or diminish the vacuum, the rate at which the liquid enters the bottle can be varied at will. This adjustment is particularly useful in filling liquids which have a tendency to froth.

When the bottle has been filled as described, the plate valve is again turned, the effect of this movement being to disconnect the interceptor from the exhausting system, and at the same time to open the third pipe in the nozzle to the atmosphere, thus allowing air to enter the neck of the bottle and break the vacuum. The liquid in the tail pipe then runs back, drawing after it the portion remaining in the nozzle, and the air entering the neck of the bottle downwards through the vacuum-breaker pipe, as it may be called, passes up the vacuum pipe in the nozzle on its way to the interceptor, thus clearing the pipe of any liquid it may contain. As a result of this action, the whole of the pipes in the nozzle are dried internally before the bottle can be taken away, and as the liquid never rises above the lower end of the nozzle there is no possibility of dripping from the latter.

An important point in connection with the vacuum-breaking arrangements may now be referred to, viz., that the rubber tube connecting the vacuum-breaker pipe in the nozzle to the plate valve is provided with a metal connection containing a small hole which is always open to the atmosphere and constitutes an air leak. The object of this is threefold: firstly, it prevents any liquid from being drawn up the vacuum-breaker pipe when the bottle is filled, and, secondly, it reduces the amount of liquid drawn up the vacuum pipe into the interceptor by providing a supply of air which is drawn up in place of the liquid. It should here be mentioned that the liquid collected in the interceptor is free to run back into the receptacle under the bench, through a tail pipe fitted with a foot valve, when the vacuum is broken. The third effect of the leak is to reduce the vacuum in the neck of the bottle to an extent just sufficient to lift the liquid up the tail pipe to the filling nozzle. Excessive vacuum would cause temporary overfilling, due to the inertia of the liquid, so that the latter would rise above the end of the nozzle and wet it externally. Actually, as already mentioned, the nozzle remains dry; neither is the inside of the bottle neck wetted above the level of the liquid.

The principles above explained are employed in the design and construction of a range of filling machines covering all ordinary requirements and having up to 16 filling heads, arranged in line or on a rotating frame. Fig. 2 is an example of a machine of the latter type, provided with six rotating filling nozzles and intended for bottling whisky. It is unnecessary to describe the machine in detail, its principle being exactly similar to that of the single-head machine described above. We may point out, however, that the machine is entirely automatic in action, the bottles, which are placed by hand on the elevating tables, being filled as they rotate, and being removed full after completing a revolution. The vacuum is made and broken in each bottle automatically by the rotation of the machine, the plate valve controlling this being located at the top of the machine as shown in the illustration. The guide rings provided to direct the neck of each bottle accurately on to the filling nozzle should be noted. The capacity of this machine, filling bottles containing ¼ gallon each, is 2,000 per hour, while with the single-head machine, operated by hand, from 1,000 to 1,500 bottles can be filled per hour, according to the size of the bottles and the character of the liquid.

A large number of the machines described above are already in use, and comparatively recently the vacuum principle has been applied by the makers to the filling of powders into cardboard boxes, tins and other forms of container. Any form of powdered, or fine granular, material, such, for example, as toilet powders, dried milk, pepper, powdered chemicals, &c., can be dealt with, and the machine has the inherent advantage that there is no escape of dust into the atmosphere. This feature is obviously of considerable importance from the point of view of the health and comfort of the operator especially when irritating or noxious powders are being handled.

The machine is illustrated by a photograph reproduced in Fig. 3 and by a sectional drawing in Fig. 4. The powder is first filled into the conical hopper of the machine by creating a vacuum in the hopper through a pipe shown on the right-hand side of Fig. 4. The pipe, it will be noticed, is connected to a loose cover resting on the top of the hopper, the necessary airtight joint being formed by a ring of soft rubber on the flange. When the vacuum is applied, the powder is drawn up through the pipe shown on the left from a barrel, or other receptacle, on the floor, this operation being carried out at intervals as required. Any powder which remains in the hopper at the end of the filling process can be returned to the barrel by removing a plug from the bottom of the pipe on which the hopper is mounted.

A flexible pipe connects the filling head of the machine to the hopper, and the former is also connected to the vacuum system through two glass interceptors arranged in series, as will be clear from Fig. 4. The covers of these interceptors are held in position by atmospheric pressure only, so that they can easily be lifted off to remove the contents when the vacuum is released. In general, the filling head is similar to that of the liquid filling machines, except that there is no depending nozzle. When filling tins, bottles, or other receptacles capable of withstanding external atmospheric pressure without collapsing, the receptacle is placed on a pneumatic elevating table, which presses it up against the lower side of the filling head when the plate valve is operated, an airtight joint being made by a ring of soft rubber. When filling thin cardboard cartons, however, they must be placed in a metal container to support the atmospheric pressure when the vacuum is applied; a container suitable for a rectangular carton can be seen in Fig. 3, tilted forward from the elevating table to which it is hinged. Further movement of the plate valve, above referred to, applies the vacuum to the box or other receptacle under the filling head, and powder from the hopper is drawn into and deposited in the box. As the powder rises filling the box, a certain amount of dust is drawn out with the air and collected in the interceptors, but the vacuum connections on the filling head are covered with fine wire gauze so that the bulk of the powder cannot be drawn up the vacuum pipe. Actually, of course, the whole system, including the hopper, is closed, so that the filling action cannot continue after as much air as possible has been extracted. At this stage the plate valve is turned to cut off the vacuum and admit air, after which the filled box can be removed and replaced by an empty one, the operation then being repeated.

From eight to twelve one-pound packets can be filled per minute in this way, and small packets, or bottles, at the rate of about 30 per minute. The packets can be filled lightly or tightly as required, the adjustment being effected by means of the vacuum-reducing valve shown on the pipe near the second interceptor on the right of Fig. 4. This, of course, controls the velocity with which the air carrying the powder enters the receptacle. By using a 25-in. vacuum, we have been given to understand, it has been found possible to pack 1 lb. 9 oz. of dried milk into a tin holding only 1 lb. when filled by hand—a matter of considerable importance in the export trade. It should perhaps be pointed out, in connection with the vacuum adjustment, that the plate valve is arranged so that the full vacuum is applied to the cylinder of the elevating table, irrespective of the setting of the reducing valve. Another point which should be mentioned, is that the outlet connections of the interceptors are fitted with filters to prevent any dust from being drawn into the vacuum main.

In conclusion, we may mention that the makers of the machines described also specialise in the design and construction of weight-controlled filling machines for paints, varnishes, and similar materials, as well as of travelling fillers for filling small shallow tins with boot polishes, &c.

THE SALVAGE OF AN EX-GERMAN TORPEDO BOAT DESTROYER.

AT the time of the first efforts made to raise the scuttled vessels of the ex-German fleet at Scapa Flow last year, we gave a description (see ENGINEERING, vol. cxviii, page 233) of the procedure that was adopted. It will be remembered that for this purpose a German floating dock, formerly used for testing submarines, was converted into two pontoons, and these were fitted with treble-geared winches by means of which the wire ropes placed beneath the hull of the vessel were hauled in to raise it. This method sufficed for the seven torpedo boat destroyers which were standing upright, but a new set of conditions were encountered by Messrs. Cox and Danks, Limited, when starting work on the rest, which were lying on their sides. Now that the first of the latter 750-ton destroyers has been successfully salved and towed to Mill Bay, it will be of interest to those concerned with the lifting of sunken sea craft if we give some details of the means that were adopted.

The equipment, which was formerly described, was again used for the purpose, but for righting the vessel it had to be utilised in a somewhat different way. It will be remembered that there are ten winches on each pontoon and that these operate on blocks and tackle, each unit providing a pull of 100 tons. Ten wire ropes, each 9 in. circumference, were placed at distances of about 20 yards under the hull. One end of each line was connected to a pulley block on the first pontoon, and the wire ropes were then passed under the hulls to the corresponding block on the other pontoon. Slack was taken up and the vessel was then lying in a cradle of wire ropes. By taking up the ropes with one set of winches and winding out with the other, it was found possible to use the friction between the ropes and the hull to turn the vessel over and put it eventually in an upright position. When this was achieved the procedure of raising the ship was that described in the earlier article, by taking up the ropes on both winch equipments at the same time. The whole of the work was thus carried out in a simple manner without undue exertion and without any slipping.

There are some points in the work, worthy of special comment. This destroyer was in such deep water, something of the order of 10 fathoms, as to allow the superstructure, consisting of funnels and bridge to be under one of the pontoons at the start of the operations. Sufficient clearance was further available, when the vessel was being pulled over, as to make it impossible for the underside of the pontoon to foul any part of the ship's structure. The torpedo boat destroyer salved was the S.136, and the log of the work shows that the tug Lyness left the pier on Thursday, March 26, with the pontoons in tow. These were moored and the actual work started on Friday morning, March 27. By Wednesday, April 1, the ship was righted and it was raised and towed into Mill Bay by Friday, April 3. In considering the time taken in this successful piece of work performed by Messrs. Cox and Danks, Limited, whose head offices are at 168, Regent-street, London, it should be remembered that nothing was done during the customary week-end break.

LABOUR NOTES.

COMPARATIVELY little interest has been taken by the rank and file of British Labour in the conferences between the General Council of the Trades Union Congress and representatives of the Russian trade unions. In some newspapers the danger of a fusion of British and Russian trade union interests has been emphasised, and there is, undoubtedly, a risk of undesirable entanglements in meetings of this particular kind. But the important facts need not be overlooked: (1) that the General Council cannot do anything decisive without the express authority of Congress, and (2) that nothing done by Congress with a direct bearing on industry, as distinct from politics, can bind the affiliated unions. The last word on all important issues lies with the trade unions themselves, whose right to ballot on them is not in the least degree doubtful. The tendency of the present General Council is, of course, unmistakably, towards the Left, and the fact that it is, constitutes, in the opinion of many thoughtful workers, a danger to the whole organised movement in this country. Congress and its General Council may conceivably, it is argued, go so far as to leave itself without the support of the affiliated unions which are the backbone of the movement.

On the main question discussed by the conference, the National Minority Movement's adherents are, as was to be expected, delighted at what they regard as success. The aim of the Communist Party, whose instrument the N.M.M. is, is avowedly to detach British Trade Unionism from the International Federation of Trade Unions and attach it to the Red International of Labour Unions. The result of the conference is, therefore, hailed by the C.P. and the N.M.M. as an important step towards the achievement of that object. The average British worker, on the other hand, takes the view, not only that the conference was profitless, but that there was no need to hold it. Nobody, he argues, is keeping the Russian trade unions out of the Amsterdam International. They can affiliate to-morrow if they accept the constitution. That is, however, exactly what the Russians are unwilling to do, and their hope is that, with the assistance of the General Council, a formula will be found that will get them out of that difficulty. Their dream is, in effect, to substitute the constitution of the Red International for that of the Amsterdam International. The rank and file of British Labour do not desire that to happen, and, through the constitutional machinery of their organisations, they will eventually make that plain enough.

That the aim of the National Minority Movement is revolutionary is frankly enough avowed by the Communists who are very busy at the moment organising the discontented of every political complexion with the object of enrolling them as adherents. Writing in the official organ of the N.M.M. one of them says :—

"The 'left wing' group, while having the sympathy and support of large masses of the workers on all issues on which they make a fight, have no organised support of any kind behind them. If the 'left wing' group is going to make a stand against the forces of the 'right,' if it is going to make a fight for leadership of the Labour Party, the sympathetic support which it is now getting must be organised. The necessity for this is becoming ever clearer to the 'left wing' group itself, and, as the party is working in this direction, the 'left wing' group is naturally being drawn closer and closer to the party. We are getting all the loose elements together and will gradually bring them into association with the Minority Movement, so that there will be the completest unity of all the 'left wing' forces in the country. The Minority Movement is growing to be a potent force in Britain. Working within this movement, we can build up a real mass revolutionary party, and when we succeed in doing so, the days of Capitalism are numbered."

All the trade unions concerned are unlikely to agree to the joint inquiry into the economic state of the shipbuilding industry proposed by Mr. John Barr, although a sufficient number will probably accept the invitation to make such an investigation possible and profitable. It is said that the Amalgamated Engineering Union has decided against the proposal. If it really has done so, the decision is, in the light of an editorial note in the April *Report*, somewhat difficult to understand. The writer of the note, "giving a personal view, welcomes . . . the shipbuilding employers' proposals." "As a matter of fact," he goes on to say, "we have on several occasions during the past few years, put forward a plea that such action should be taken, and we fully concur with Mr. Barr's concluding statement, viz., 'that if we are to secure restoration of our industry it will be by common desire on the part of both employers and employed working for the same end.'"

In March the home branch membership of the Amalgamated Engineering Union decreased from 213,483 to 213,341, and the Colonial branch membership from 25,727 to 25,544. The number of unemployed members increased from 15,706 to 15,878. The percentage of unemployed members, reckoned in the usual way, is now 7·23.

The National Committee of the Amalgamated Engineering Union is to meet towards the end of next month, and resolutions for its consideration are now being sent in by local units of the organisation. Divisional Committee No. 16, at a meeting in Liverpool decided to submit the following :—"That the National Committee instruct the E.C. to put an end to all national negotiations on the ground that they are unprofitable and abortive. The lengthy and abnormal delays which take place with questions on national lines tends to sap and destroy the morale of our members. We, therefore, ask for the reversion to local negotiations which will speed up matters and be of more benefit to our members. Under national considerations of many questions there have been years of wasted labour. Under local considerations negotiations would be speedier, and more effective results would follow." For reasons which are not obscure the Engineering and Allied Employers National Federation is unlikely to acquiesce in a change of that kind. Even from the operatives' point of view, the proposal has defects which are fatal to it. One is that while reversion to local considerations might benefit some areas it would work out most disadvantageously for others. The framers of the resolution are apparently, however, not very seriously desirous of a change, for in another resolution passed by them, the executive council is instructed "to take steps with the Engineering and Allied Employers National Federation" to arrive at an agreement regarding the control and wages of apprentices.

Arising out of the formation of the Steel Constructors' Union—which is stated to be making satisfactory progress—a co-operative organisation for the training of workers has been registered under the title of the National Training and Trading Utility Society. Five per cent. will be paid on invested capital, and the surplus will be devoted to training unskilled men in the construction and erection of houses, not only of the new steel type, but also of the cement and wood types. The society is prepared to undertake work for municipalities as well as for private individuals. An appeal is being made for share capital and loan capital. The society has already received a number of inquiries with regard to the erection of houses from private individuals, and it has been appointed sole concessionnaire in connection with the Roach-Cumming system of insulated houses.

Evidence submitted by representatives of the Federation of Master Cotton Spinners Associations, Limited, to the Committee on Industry and Trade contained interesting information on working hours. The witnesses explained that the working hours are at present limited by joint agreement to 48 per week, but the Federation of Master Cotton Spinners' Associations thought this number should be regarded as a minimum, and that if it were maintained while foreign competitors were working longer hours they feared that a large portion of the trade would leave Lancashire. They expressed their opinion that the decline in our trade with certain markets was due partly to our competitors having an advantage in the matter of longer working hours. They considered that, though the efficiency of labour in this country since the war might not be quite up to the standard which obtained previously, the Lancashire cotton operatives, speaking generally, compared very favourably in efficiency with operatives in foreign countries, but that if the foreign mills were permitted to run substantially in excess of eight hours each day the increase in the producing capacity of the spindles would confer a substantial advantage. Attention was also called to the handicap on industry in this country, as compared with foreign competitors, owing to the heavier taxation levied, and the opinion was expressed that with reduced taxation and increased effective working hours in this country our commercial supremacy, so far as cotton goods are concerned, could not be seriously challenged.

On the motion for the adjournment of Parliament last week, Mr. Tom Shaw pressed for the ratification of the Washington Convention establishing a 48-hour week, declaring that if Britain's word was still its bond the Government had no alternative. While we ought to be in the vanguard, he said, we were the only nation in Europe that had made no declaration in favour of ratification, conditionally or unconditionally. Sir A. Steel-Maitland, the Minister of Labour, replied that while the Government could not agree to the ratification of the hours' convention, the general objects of it had already been almost completely achieved in this country. Neither the present nor any previous Government had found it possible to frame a Bill which would conform to the terms of the Convention in its present form, and would not involve the abrogation of existing agreements in important industries and greatly impair, if not destroy, that elasticity and reasonable freedom and self-government which both employers and employed in British industry rightly prized.

The Labour Party's Hours of Industrial Employment Bill, which seeks to give legislative sanction to the Washington 48 hours' Week Convention comes up for second reading on May 1. The following reasoned amendment is to be moved by a group of Conservatives, who expect to get the official support of the Government :—"That in the opinion of this House it will be injurious to industry and increase unemployment to give effect at the present time to the provisions of the draft Washington Convention in this country; and further, this House is of opinion that these provisions can only be effectively introduced by simultaneous legislative action in all the countries whose representatives were signatories to the draft convention."

An interesting proposal, which has for its object the reduction of the country's present heavy burden of unemployment, has been made by Sir Alfred Mond. The idea, which was first mooted in 1922 when Sir Alfred was a member of the Government, is that where an employer is agreeable to employ men at their trades in excess of the normal requirement, the unemployment benefit due to the additional men employed should be given to him as a sort of subsidy. Such an arrangement would, obviously, work out to the advantage not only of employers and workpeople but also to the community. With this assistance, the employer would be able to compete with a better chance of success against his foreign rivals, the men would get work at their own trades and at trade union rates of wages, and the community would gain through the fact that the unemployment benefit disbursed was productively, instead of unproductively, expended. The Minister of Labour is understood to be considering the matter.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—We are informed that the price of the recently published volume of Transactions of the American Society of Engineers, given on page 288 of our issue of February 20 of this year as 12 dols., should have read 16 dols.

MARINE TYPE TRIPLE-EXPANSION PUMPING ENGINE.

THE pumping engine which we illustrate in Figs. 1 and 2, pages 478 and 479, has recently been supplied by Messrs. Hathorn Davey and Co., Limited, to the Poole Corporation. The engine is of the triple-expansion, vertical marine type, having cylinder diameters of 15 in., 25 in. and 40 in., with a stroke of 36 in., and runs at 23 r.p.m. It is fitted with Corliss valve gear of standard design, operated from a lay-shaft, and having cams and eccentrics at cylinder level. The valve gear is controlled by an adjustable high-speed governor. A safety trip gear, which can be seen below the governor in the illustrations, is fitted. This gear automatically stops the engine in case of a rise in pressure in the mains, such as would occur if a sluice valve were closed at starting, and also performs the same function in case of loss of load due to a broken pipe or similar cause. The engine cylinders are steam jacketed, reheaters which are supplied with boiler steam being provided. These can be seen in the figures mounted on seatings cast on the rear side of the main engine columns. After leaving the low-pressure cylinder, the steam passes through the exhaust pipe to an oil separator, and thence through a feed-water heater to an open-type surface condensing plant immersed in the well. Forced lubrication is provided for the piston rods, valve spindles, and all parts subject to steam pressure, with continuous sight-feed lubrication to all bearings.

The steam-raising plant consists of two Cornish boilers, manufactured by Messrs. H. and T. Danks, of Netherton, each boiler being 6 ft. diameter by 20 ft. long, and having a grate area of 19 sq. ft. The heating surface is 444 sq. ft. and the working pressure is 180 lb. per square inch. The equipment includes a Green economiser and a superheater supplied by Messrs. Ferguson Superheaters, Limited, of London. The latter gives 150 deg. F. to 200 deg. F. superheat.

TABLE I.—*Engines and Pumps.*

Duration of test			10 hours.
Total steam used			20·95 lb. per min.
Temperature of air pump discharge			67·0 deg. F.
Temperature of combined discharge			106·0 deg. F.
Pressure of steam at boiler side of stop valve			196·56 lb. per sq. in abs.
Average superheat at engine stop valve			123·0 deg. F.
Vacuum in condenser			27·1 in. Hg.
Average m.e.p. from indicator cards—	H.P.	I.P.	L.P.
Top end	63·30	16·23	6·28
Bottom end	61·81	16·49	6·37
Head on borehole pumps	38·18 ft.		
Delivery head	284·79 ft.		
Revolutions per minute (average by counter)	23·6.		

I.H.P.—	H.P.	I.P.	L.P.
Top end	24	17·1	16·94
Bottom end	22	16·95	17·01
Total	46	34·05	33·95 = 114 I.h.p.

Steam per I.h.p. per hour	11·04 lb.
Swept volume of two bucket pumps	7·484 cub. ft. per rev.
Work done by bucket pumps	420,800 ft.-lb. per min.
Swept volume of three force pumps	7·216 cub. ft. per rev.
Work done by force pumps	3,027,000 ft.-lb. per min.
Total work done by pumps	3,447,800 ft.-lb. per min.
Work done per 1,000 lb. of steam	164,600,000 ft.-lb.
Pump horse-power	104·5.
Mechanical efficiency overall	91·7 per cent.
Steam per p.h.p. per hour	12·04 lb.

TABLE II.—*Boilers.*

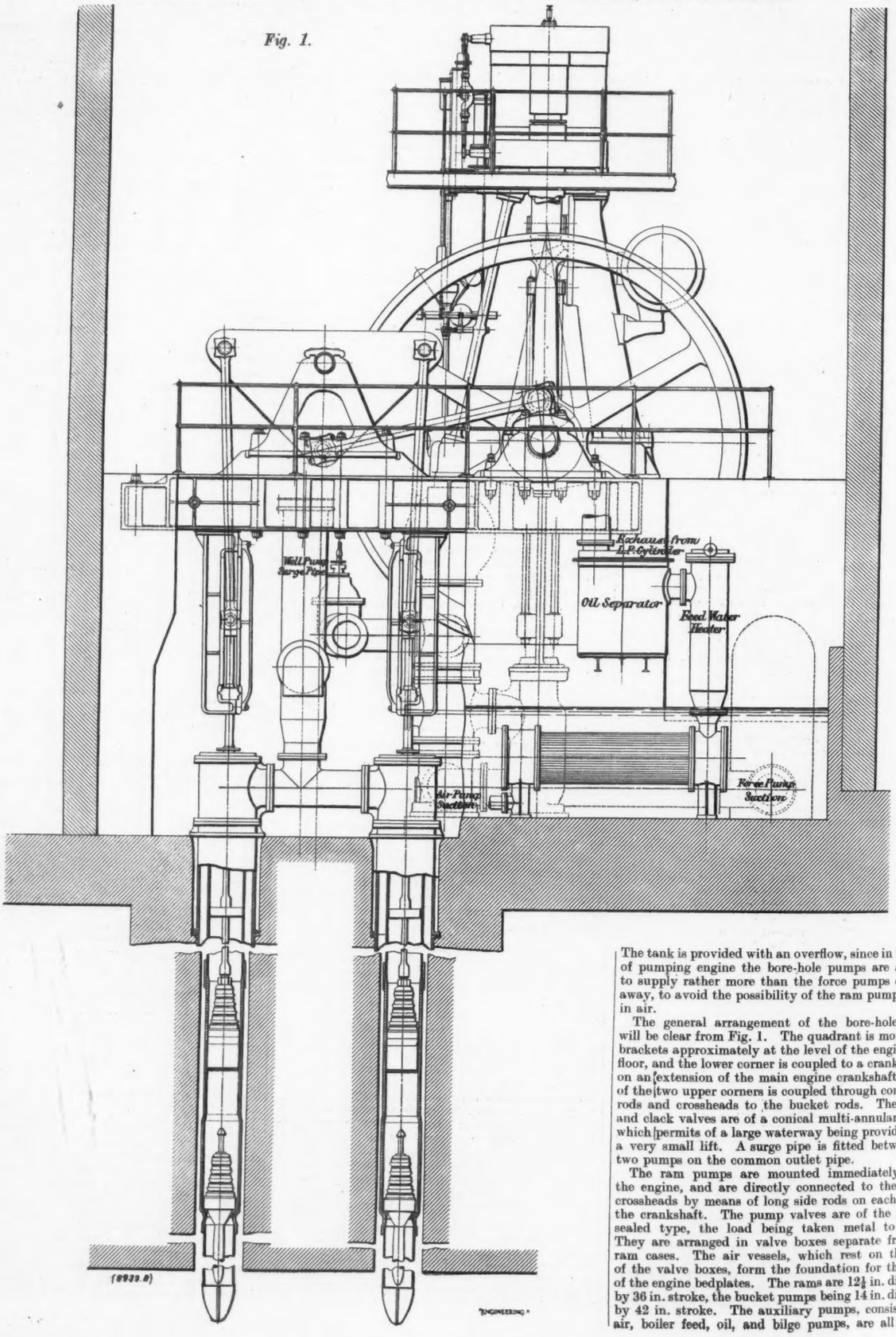
Duration of test	10 hrs. 3 min.
Total coal used	1,762 lb.
Total weight of ash	343·25 lb.
Boiler pressure (gauge)	181·86 lb. per sq. in.
Temperature of steam at engine	502·8 deg. F.
Average superheat at engine	123 deg. F.
Inlet temperature of feed to economiser	99·32 deg. F.
Outlet temperature of feed from economiser	229·27 deg. F.
Lower calorific value of fuel as fired, in absence of complete analysis, taken at	14,200 B.Th.U. per lb.
Total coal used per minute	2·02 lb.
Actual evaporation per lb. of coal fired	7·17 lb.
Equivalent evaporation from and at 212 deg. F. per lb. (boiler and economiser)	8·87 lb.
Allowing 30 deg. F. loss of superheat between boiler and engine, and assuming coal of 13,000 B.Th.U. per lb., to correspond with guarantee, equivalent evaporation from and at 212 deg. F. would be	8 32 lb. per lb. of coal.
Crediting boiler with 2½ per cent. leakage in computing actual quantity evaporated—	
Equivalent evaporation corresponding with guarantee	= 8·53 lb. per lb. of coal.

The engine drives two sets of pumps, one set of single-acting three-throw force pumps being direct driven by the engine, and a pair of single-acting bucket pumps being driven from an extension of the engine crankshaft through the medium of a quadrant. The bucket pumps draw from two bore holes in which the pumping level is approximately 150 ft. below the surface, and deliver to a tank below the floor level of the engine house. The force pumps feed from this tank and deliver into the mains, and are designed to work against a head of 225 ft. The quantity of water delivered into the mains is 1,000 gallons per minute.

MARINE TYPE TRIPLE-EXPANSION PUMPING ENGINE.

CONSTRUCTED BY MESSRS. HATHORN, DAVEY AND CO., LIMITED, ENGINEERS, LEEDS.

Fig. 1.



The tank is provided with an overflow, since in this type of pumping engine the bore-hole pumps are arranged to supply rather more than the force pumps can take away, to avoid the possibility of the ram pumps taking in air.

The general arrangement of the bore-hole pumps will be clear from Fig. 1. The quadrant is mounted in brackets approximately at the level of the engine-room floor, and the lower corner is coupled to a crank formed on an extension of the main engine crankshaft. Each of the two upper corners is coupled through connecting rods and crossheads to the bucket rods. The bucket and clack valves are of a conical multi-annular design, which permits of a large waterway being provided with a very small lift. A surge pipe is fitted between the two pumps on the common outlet pipe.

The ram pumps are mounted immediately below the engine, and are directly connected to the engine crossheads by means of long side rods on each side of the crankshaft. The pump valves are of the leather-sealed type, the load being taken metal to metal. They are arranged in valve boxes separate from the ram cases. The air vessels, which rest on the tops of the valve boxes, form the foundation for the front of the engine bedplates. The rams are 12¼ in. diameter by 36 in. stroke, the bucket pumps being 14 in. diameter by 42 in. stroke. The auxiliary pumps, consisting of air, boiler feed, oil, and bilge pumps, are all driven

MARINE TYPE TRIPLE-EXPANSION PUMPING ENGINE.

CONSTRUCTED BY MESSRS. HATHORN, DAVEY AND CO., LIMITED, ENGINEERS, LEEDS.

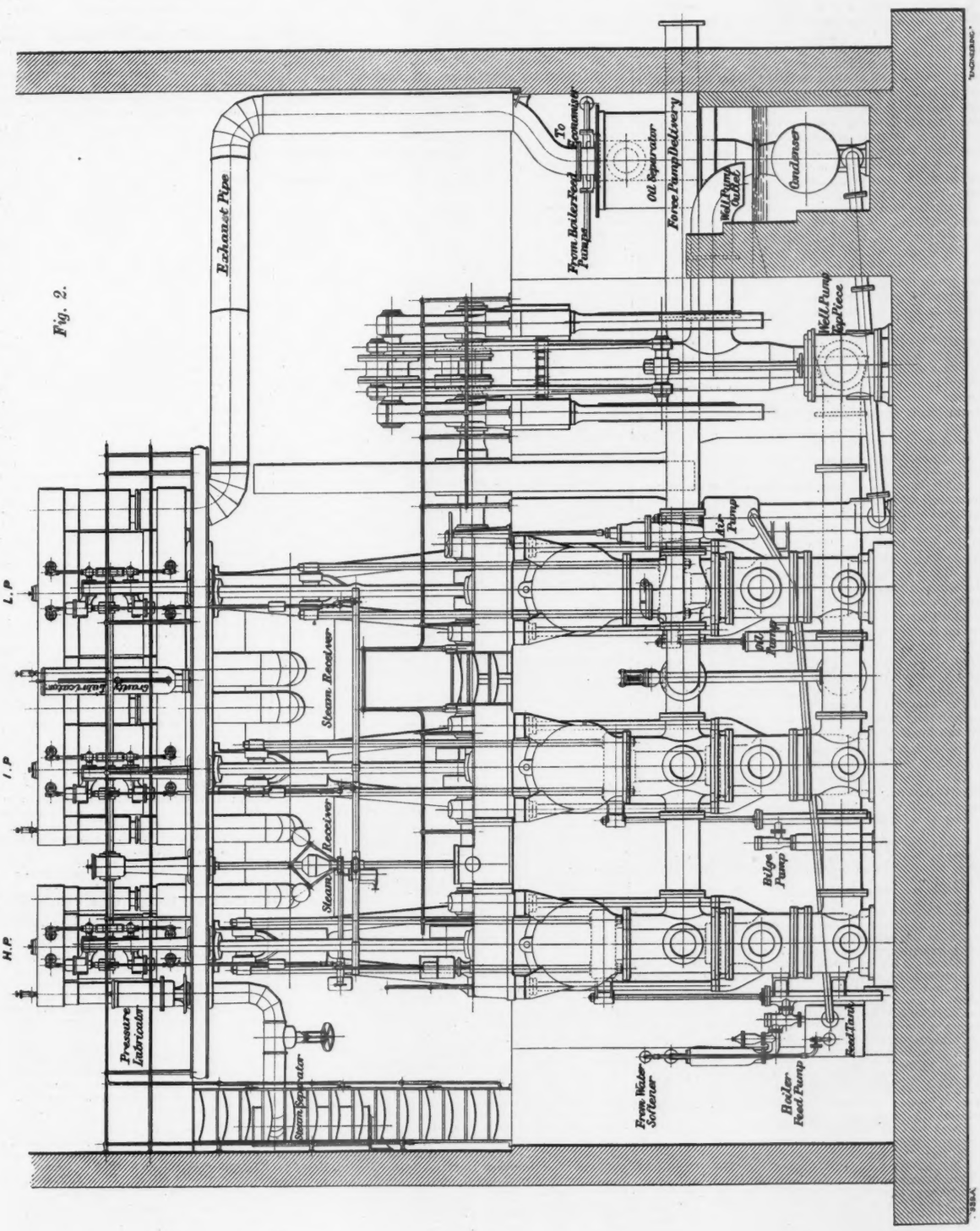


Fig. 2.

from the main ram pump crossheads, so that no auxiliary steam is required for this plant other than the small quantity used by the economiser scraper engine.

After completion, a test was carried out on the pumping set by Professor A. Robertson, of Bristol University. The duty guarantee to be fulfilled by the makers was for a delivery of approximately 1,000 gallons of water per minute against a total inclusive head of not less than 320 ft. at an engine speed of 23 r.p.m., the duty per 1,000 lb. of dry steam at 180 lb. per square inch pressure and superheated to 150 deg. F. not being less than 150 million foot-pounds. A margin of 2½ per cent. to be allowed to cover errors in measurement. The boiler guarantee was that, assuming the coal to have a calorific value of 13,000 B.Th.U. per pound, the boilers were required to give an evaporation of 8·5 lb. of water, from and at 212 deg. F., per pound of coal when working at their full rated capacity.

The result of the test made by Professor Robertson on the engine and pumps are given in Table I, and on the boilers in Table II, both on page 477.

It will be seen from these tables that the engine, of which the duty was guaranteed at 150 million foot-pounds per 1,000 lb. of steam, actually gave a duty of 164·6 millions, an excess of nearly 10 per cent. This corresponds to a steam consumption of 12·04 lb. per pump horse-power hour. The boiler equivalent evaporation was guaranteed at 8·5 lb. of water per pound of coal, but the actual figure on the test was 8·53 lb. In this connection, however, Professor Robertson points out in his report that an allowance of 2½ per cent. for leakage and other errors is very low. In the absence of facilities for measuring the actual water pumped into the boiler, steam consumption figures were regarded as equivalent, so that any steam losses on the engine were debited against the boiler.

It may be mentioned in connection with the tests that the air pump discharge, jacket drains, interheater drains, and the water from the oil separator discharge were all led into a common tank. The water was drawn off from this to a second tank on a weighing machine, and the time required to collect successive 6-cwt. lots observed. Indicator diagrams were taken at frequent intervals. The depth of the water level in the well in relation to the level in the surface tank was observed at regular intervals, and the mean over the whole 10 hours' test was 38·18 ft. In order to obtain the total head specified, it was found necessary to throttle the delivery of the water by partially closing the main sluice valve. The average total head against which the force pumps worked was 284·79 ft. The quantity of water pumped was determined in accordance with the specification as being the actual swept volume of the plungers, that is, the volumetric efficiency of the pumps was assumed to be unity. As a check against this, it may be noted that the rate of pumping by the force pumps was 63,660 gallons per hour on this assumption, and 62,200 gallons, as given by the reading of the venturi meter.

The consulting engineers for the pumping plant were Messrs. A. P. I. Cotterell and Son, Westminster.

CALENDAR.—We have received from the British Electric Plant Company, Limited, of Alloa, Scotland, a large size illustrated monthly tear-off calendar for the years 1925–27.

THE IRON AND STEEL INSTITUTE.—The spring meeting of the Iron and Steel Institute will take place on May 7 and 8, in the hall of the Institution of Civil Engineers, commencing at 10 a.m. each day. On Thursday the new president, Sir Frederick Mills, Bart., will take the chair and will present the Bessemer Medal to Professor T. Turner. The papers to be read and discussed are as follows:—"The Effect of Grain upon the Fatigue Strength of Steels," by Dr. L. Aitchison and Mr. L. W. Johnson; "A Method for reducing the Percentage of Phosphorus in Swedish Iron by diminishing the Phosphorus in the Charcoal," by Dr. H. von Eckermann; "On the Structure of Quenched Carbon Steels," by Mr. B. D. Enlund; "Estimation of Phosphorus in the presence of Vanadium," by Messrs. G. Watson Gray and C. D. Garbutt; "Temper-brittleness of Steel; Susceptibility to Temper-brittleness in relation to Chemical Composition," by Messrs. R. H. Greaves and J. A. Jones; "Note on Nitrogen as a possible Factor in Temper-brittleness," by Mr. W. T. Griffiths; "Progress in British Rolling-Mill Practice," by Mr. T. W. Hand; "'Flakes' or 'Hair Cracks' in Chromium Steel, with a discussion on 'Shattered Zones' and 'Transverse Fissures in Rails," by Mr. A. Hultgren; "'Peeling' in White Heart Malleable," by Messrs. D. H. Ingall and H. Field; "The Influence of Gases at High Temperatures upon Iron, with special reference to the Formation of Blow-holes," by Messrs. A. G. Lobley and C. L. Betts; "Some Notes on the Use of a Diamond Pyramid for Hardness Testing," by Messrs. R. L. Smith and G. E. Sandland; "The Detection of Strain in Mild Steels," by Messrs. T. Henry Turner and J. D. Jevons; "Strain Detection in Mild Steel by Special Etching," by Mr. J. D. Jevons; "Observations on Martensite and Troostite," by Mr. J. H. Whiteley. The annual dinner will be held on Thursday evening, May 7, in the Grand Hall of the Hotel Cecil, Strand, W.C. 2.

REFRIGERATED FRUIT STORAGE.

THE Food Investigation Board, continuing the publication of the results of its successful Australian expedition, has now published two more reports on the subject,* which, though adding little to the general conclusions it has already announced, provide detailed confirmation of the conclusions at which its investigators arrived. The ventilation of refrigerated ships' holds for the carriage of fruit seems to be technically a matter of no great difficulty, though this might not be expected in view of the speed at which the apple cargo of a hold fouls its atmosphere. It need be done only at relatively long intervals, when the percentage of carbon dioxide is approaching the danger limit, and the amount of air to be discharged or introduced, according to the method adopted for changing the atmosphere, is no more than can be shifted by a portable electric fan. A matter that remains for further consideration is the practicability of pre-cooling the fruit. Such an operation, if done on shore, would relieve the ship of a relatively troublesome and costly business, and undoubtedly help to extend the life of the fruit in cold store. It would be particularly desirable if it could be done as soon as the fruit was gathered; but, whenever it is done, the temperature has to be kept down till the fruit is out of store, and transit and storage in such conditions may sometimes be neither cheap, convenient, nor even practicable. The reports are, in any case, a reminder that not only unsolved problems are still to be found in the cold storage and transport business, but that those who use cold stores are taking increased interest in them, though in some parts suitable accommodation seems to be unduly scarce.

BOOKS RECEIVED.

The Construction of Wells and Boreholes for Water Supply and the Elements of the Analysis and Purification of Water. By J. E. DUMBLETON. London: Crosby Lockwood and Son. [Price 10*s.* 6*d.* net.]

American Society for Testing Materials. Vol. XXIV. *Proceedings of the Twenty-seventh Annual Meeting, Atlantic City, New Jersey. June* 24-27, 1924, Part I. *Committee Reports. New and Revised Tentative Standards.* Part II. *Technical Papers,* Philadelphia, Pa.; American Society for Testing Materials.

Die Edelstähle. Ihre metallurgischen Grundlagen. By Dr. ING. F. RAPATZ. Berlin: Julius Springer. [Price 12 gold marks.]

The Colliery Year Book and Coal Trades Directory, 1925. London: The Louis Cassier Company, Limited. [Price 21*s.* net.]

Practical Humidity Tables for Engineers, Textile Manufacturers, &c. Compiled by the Technical Staff of MESSRS. A. B. CLEWORTH AND CO., LIMITED. London: Taylor and Francis. [Price 6*s.* net.]

Reports of the Progress of Applied Chemistry. Vol. IX—1924. Issued by the Society of Chemical Industry. London: Society of Chemical Industry. [Price 7*s.* 6*d.* Non-members 12*s.* 6*d.*]

The Rigid Airship. A Treatise on the Design and Performance. By E. H. LEWITT, B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 30*s.* net.]

Low-Temperature Distillation. Home Oil Supply and the Utilisation of Waste Coal. By SYDNEY H. NORTH and J. B. GARBE. London: Sir Isaac Pitman and Sons, Limited. [Price 15*s.* net.]

Molybdenum, Cerium, and Related Alloy Steels. By H. W. GILLETT and E. L. MACK. New York: The Chemical Catalog Company, Inc.

CONTRACTS.—The Mirrlees Watson Company, Limited, of Scotland-street, Glasgow, has secured amongst other contracts an order for two evaporators, each capable of supplying 5,700 lb. of feed water per hour, and intended for service at the Dalmarnock Power Station, Glasgow. The same company will provide, for Wigan Corporation Pemberton Sewage Pump Station, three 12-in. centrifugal pumps, each capable of delivering 3,000 gallons per minute against a total head of 40 ft. when running at 720 r.p.m.—The Vickers-Spearing Boiler Company, Limited, of 20, Kingsway, London, W.C. 2, has received an order from the Thames Board Mills, Limited, for four "Spearing" boilers, having a combined normal evaporation of 100,000 lb. per hour at a working pressure of 350 lb. per square inch.—Messrs. John Hands and Sons, Limited, of Cardigan Works, Birmingham, manufacturers of dies, shearing machines, &c., have recently received an order from the India Office for a large high-speed guillotine shears of the overhead crank type.—Messrs. Howden-Ljungström Preheaters (Land), Limited, of 133, Helen-street, Govan, Glasgow, have received an order to supply a preheater, having a heating area of 26,700 sq. ft., to Messrs. Hurst Nelson and Co., Limited, of Motherwell.—Messrs. James Pollock and Co., Limited, of 3, Lloyds-avenue, London, E.C. 3, have received a contract to supply a 100 brake horse-power Bolinder engine for the vessel Innishowen, originally built for the Coasting Motor Shipping Company, of Glasgow.

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*Special Report, No. 21. "The 'Gas' Content and Ventilation of Refrigerated Holds Carrying Apples." H.M. Stationery Office. 1*s.* 3*d.*

Special Report, No. 22. Brown Heart in Australian Apple Shipments." H.M. Stationery Office. 1*s.* 3*d.*

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—The slump in South Yorkshire coal trade via Hull is unchecked. The latest official return for last month reveal a further decrease in receipts from this district of 56,000 tons as compared with March last year, bringing the total fall for the first quarter of the present year to no less than 120,000 tons as against a year ago. The continued contraction in exports is again the main cause of this disquieting state of affairs. The total tonnage sent to Germany last month was less than one-tenth of that for March, 1924, while France took only 38,000 tons as compared with 68,000 tons in the corresponding month last year. On the other hand, an increased business was done with South America, Belgium, Denmark, Iceland, and Italy.

Iron and Steel.—The holiday period at local steel and engineering works is this year more varied than usual on account of the exceptionally mixed conditions obtaining. A few of the more favoured sections resumed operations to-day after a set-down of two to four days, but in many cases where bookings are very thin the stoppage will be one of seven to ten days' duration. Advantage is being taken of this respite to overhaul plant and execute repairs. Inquiries received during the past week fail to afford any substantial indication of an improvement in the early future. The prevailing undertone is still one of quiet confidence in ultimate recovery, though it appears certain, according to leading manufacturers, that the difficulties of the past two years are likely to be repeated over the next six months, and that some of the leading branches will have a hard task to keep plant operating at equal capacity. There is very little movement in any section of the market for raw or semi-finished materials. Pressure of sales in cheap Continental billets badly hampers production at local furnaces. Purchases of hematites and scrap are confined in the main to bare requirements to cover immediate necessities, and prices, on the whole, are distinctly weak. The shipbuilding and engineering trades, taken as a whole, are furnishing a fair volume of orders, but the amount of work in progress and awaiting execution is nothing like sufficient to employ plant profitably. The latest reports from representative firms only serve to stress the difficulty experienced in keeping machinery running, and provide further confirmation of the almost generally adopted policy of taking orders at a price level which excludes possibility of reasonable profit but has the important result of keeping staffs employed. Production in the lighter steel trades, which showed signs of revival, has in some instances again begun to decline.

South Yorkshire Coal Trade.—Nothing has occurred during the holiday stoppage to improve the general outlook. Conditions in steam fuel appear to be going from bad to worse. Home demands, particularly on railway account, are responsible for substantial deliveries inland, but as so many collieries rely largely on export requirements, which show a further shrinkage, the position to say the least, is unsatisfactory. There is some call for washed slacks, but inferior grades and cobbles and nuts show considerable weakness. The coke trade reflects the condition of the export market, prices generally being easy. Orders for house coal have accumulated during the holidays, but merchants will have no difficulty in working these off from depot supplies. Quotations:—Best branch hand-picked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 28*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 20*s.* to 24*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; smalls, 4*s.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Only moderate quantities of Cleveland pig-iron are available for prompt sale, makers' undisposed-of stocks being small, and merchants having only limited parcels to offer, but, notwithstanding such healthy statistical conditions, values are distinctly easy. At the same time, it is fully realised that circumstances are such as warrant cautious dealing. Very little improvement in demand might speedily materially alter the situation by causing prices to rise and creating shortage of supply. At present customers confine their operations to purchases sufficient to meet early needs. No. 1 is 82*s.*; No. 3 g.m.b., 77*s.*; No. 4 foundry, 76*s.*; and No. 4 forge, 75*s.*

Hematite.—East Coast hematite is plentiful, accumulations at producers' works being heavy, and quotations tend downward, notwithstanding prospects of curtailed output and the fact that hematite prices are already comparatively cheap. Nos. 1, 2, and 3 are obtainable at 82*s.* 6*d.*, and No. 1 is quoted 83*s.*

Foreign Ore.—Business in imported ore is unheard of, and in the absence of transactions market rates are nominal on the basis of best rubio at 22*s.* c.i.f. Tees.

Blast-furnace Coke.—Durham blast-furnace coke is in very ample supply, and good average qualities are offered at 22*s.* 6*d.* delivered to local users.

Manufactured Iron and Steel.—Demand for manufactured iron and steel continues disappointing, and, with several firms depending on hand-to-mouth orders to keep plant in operation, much apprehension is felt as regards the future. Among the principal market quotations are:—Common iron bars, 12*l.*; iron rivets, 14*l.* 5*s.*;

packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel ship, bridge and tank plates, 8*l.* 17*s.* 6*d.*; steel angles, 8*l.* 12*s.* 6*d.*; steel joists, 8*l.* 12*s.* 6*d.*; heavy steel rails, 9*l.*; and galvanised corrugated sheets (No. 24 gauge, in bundles), 16*l.* 15*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the steel trade of Scotland there is no change to report. Makers are very hard put to it to keep things going, there is so little business passing, as consumers are only specifying their day-to-day requirements, and these are indeed small. When the trend of general trade will get better it is difficult to say, but at the moment none can see the dawn of a brighter era, and it would almost seem as if this was to be one of our poorest years. Shipbuilders not having much to turn to themselves, cannot be expected to give out orders, and as most industries are suffering from a lack of demand the outlook for the steel trade is far from bright. Black sheets on the whole are only doing tolerably well, and the demand for galvanised sorts is perhaps not just so brisk. Prices are being maintained, but favourable lots are keenly competed for. The following are the current market quotations:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 10*s.* per ton; sections, 9*l.* 5*s.* per ton; and sheets, $\frac{1}{16}$ in. to $\frac{1}{4}$ in., 11*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—A depressed state still prevails in the West of Scotland malleable iron trade and orders for bar iron, although a shade better, are exceedingly difficult to pick up. Inquiries are also very scarce. Business in re-rolled steel is holding on wonderfully well, but very keen prices have to be quoted to secure orders. Export trade overall is not of any moment. Prices show a decline as makers have cut their quotations in order to try to induce buying, but so far with little result.

Scottish Pig-Iron Trade.—No change of any kind has taken place in the Scottish pig-iron trade during the past week and sales are about as low as they could possibly be. Home consumers are taking very poor deliveries, while the export trade is nearing vanishing point. The prices which have to be accepted at the present time are not remunerative, and with stocks so heavy there is a growing tendency on the part of the iron masters to curtail production considerably—small as it is at present. To-day's quotations are:—Hematite, 4*l.* 11*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 10*s.* 6*s.* per ton, and No. 3, 4*l.* 8*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, April 11, amounted to 451 tons. Of that total 191 tons went overseas and 260 tons went coastwise. For the corresponding week of last year the figures were 1,127 tons to foreign destinations and 223 tons coastwise, making a total shipment of 1,350 tons.

Shipbuilding.—The Ailsa Shipbuilding Company, Limited, of Troon and Ayr, has received an order from Messrs. John Kelly, Limited, Belfast, to build a coasting steamer. The hull will be built at the Ayr shipyard and the propelling machinery at the firm's engine works in Troon.

Locomotive Contracts.—The North British Locomotive Company, Limited, Springburn, Glasgow, has received a further order for four locomotives of the modified Fairlie type, for the South African Government Railway. An experimental engine of this type was recently built by them for the same railway, but this latest order is for a larger type.

PERSONAL.—It is announced by Messrs. Alfred J. Amsler and Co., Limited, of Schaffhouse, Switzerland, that Messrs. T. C. Howden and Co., of 191, Corporation-street, Birmingham, have been appointed sole representatives in Great Britain and Ireland for the sale of Amsler testing machines and precision measuring instruments, in succession to Mr. T. J. Primrose, of Manchester, who has retired.

PASSENGER FERRY STEAMER FOR LAGOS.—On February 24 Messrs. John I. Thornycroft and Co., Limited, launched a shallow-draught twin-screw steel passenger ferry steamer, the Kathleen, from their Woolston Works, Southampton. The vessel is being constructed to the order of the Crown Agents for the Colonies, under the supervision of Messrs. Wells and Kemp, consulting naval architects and marine engineers, of St. Stephen's House, Westminster, and is intended for service at Lagos, Nigeria. Designed to carry 800 passengers in addition to cargo, the Kathleen has a length of 123 ft. 9 ins, a breadth of 25 ft., while, when fully loaded, the draught will be 5 ft. 6 in. only. The propelling machinery will consist of two sets of compound surface condensing engines having cylinders 11¼ in. and 24½ in. in diameter, with a stroke of 16 in. The reversing engines are of the direct acting type. With the engines working at 200 r.p.m. a speed of 11 knots will be attained. The condenser is separate from the main engines. A single-ring Michell thrust block is fitted. Steam is generated in two boilers of the return tube type working at a pressure of 150 lb. per square inch, and having internal diameters of 10 ft. 9 in. and lengths of 10 ft. 6 in. Each possesses two corrugated furnaces. All auxiliaries are independent of the main engines. The deck machinery includes steam and hand steering gear.

NOTICES OF MEETINGS.

THE DIESEL ENGINE USERS' ASSOCIATION.—To-night at the Engineers' Club, Coventry-street, W. 1. "Recent Oil-Engine Developments," by Mr. J. L. Chaloner.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m., at 39, Victoria-street, S.W. 1. Ordinary Meeting. "Vertical Retorts," by Mr. Walter T. Dunn, M.I.Mech.E. Friday, April 24, at 7.30 p.m. Lecturette: "The Manufacture of Gramophone Records," by Mr. H. E. Cowley.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: YORKSHIRE DISTRICT.—Saturday, April 18, at 2.30 p.m., at the Town Hall, Wakefield. "Building Bye-laws," by Mr. A. Rothera.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH, JUNIOR SECTION.—Saturday, April 18, at 6.30 p.m., at the College of Technology, Manchester. Annual General Meeting. Lecture, "Foundry Materials," by Mr. A. Hill.

THE INSTITUTION OF AUTOMOBILE ENGINEERS: BIRMINGHAM CENTRE.—Monday, April 20, at 7 p.m., at the Chamber of Commerce, New-street, Birmingham. "Brakes for Motor Vehicles," by Mr. Geo. W. Watson.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, April 20, at 7 p.m., at Savoy-place, Victoria-embankment, W.C. 2. Informal Meeting. Discussion on "Latter-day Wireless," opened by Mr. M. Hart. Thursday, April 23, at 6 p.m. Ordinary Meeting. "Recent Improvements in the Insulation of Electrical Machinery," by Lieut.-Col. K. G. Maxwell and Mr. A. Monkhouse.

THE ROYAL SOCIETY OF ARTS.—Monday, April 20, at 8 p.m., at John-street, Adelphi, W.C. 2. Howard Lectures: "Motor Fuels (Lecture 1)," by Professor John S. S. Brame, F.I.C., F.C.S. Wednesday, April 22, at 8 p.m., Ordinary Meeting, "Bookbinding," by Mr. Cedric Chivers.

THE ROYAL METEOROLOGICAL SOCIETY.—Seventy-Fifth Anniversary Celebration. Tuesday, April 21, and Wednesday, April 22, at 49, Cromwell-road, S.W. 7. Tuesday, April 21, at 3 p.m. Visit to Kew Observatory; at 8 p.m., Conversazione. Wednesday, April 22, at 3 p.m. Commemoration Meeting. Popular lecture by Professor E. van Everdingen. At 8 p.m., Dinner at the Hotel Rembrandt, Thurloe-place, South Kensington, S.W. 7.

THE NEWCOMEN SOCIETY.—Tuesday, April 21, at 5 p.m., at the University College, Gower-street, W.C. 1. "Glass-making in Egypt," by Sir Flinders Petrie, F.R.S. "Chiddingfold Glass and its Makers in the Middle Ages," by Mrs. Brenda C. Halahan. (1) "The Inter-relationship of the Glassmakers in Western Europe"; (2) "Glassmaking under the Roman Empire," by Mr. E. W. Hulme, B.A.

THE INSTITUTE OF TRANSPORT: GRADUATES AND STUDENTS' MEETING.—Tuesday, April 21, at 5.30 p.m., at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C. 2. Lecture: "Claims (Passenger)," by Mr. S. Newman.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 21, at 6 p.m., at Great George-street, S.W.1. Ordinary Meeting. Paper to be submitted for discussion, "The Johore Causeway," by Mr. Donald Paterson. Wednesday, April 22, at 6 p.m. Students' Meeting. Annual General Meeting of the Association of London Students.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, April 21, at 7.30 p.m., at 39, Elmbank-crescent, Glasgow. "Aerodynamics of the Rotating Cylinder," by Mr. Alexander Thom.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, April 22, at 2.45 p.m., at the University, St. George's-square, Sheffield. Annual General Meeting. Lecture, "Glass as an Instrument of Human Progress," by Professor W. E. S. Turner, D.Sc. Exhibition by Mr. F. E. Lamplough, M.A., of (*a*) Daylight Lamp, (*b*) A New Glass for Transmitting Ultra-Violet Rays.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Wednesday, April 22, at 7.30 p.m., at the Engineers' Club, Coventry-street, W.1. "Press Tool Work," by Mr. F. P. Turner.

THE INSTITUTION OF MECHANICAL ENGINEERS: YORKSHIRE BRANCH.—Wednesday, April 22, at 7.30 p.m., at the Brown-Firth Research Laboratories, Sheffield. "Some Fallacies concerning Invention," by Professor G. F. Charnock.

THE INSTITUTION OF CHEMICAL ENGINEERS.—Wednesday, April 22, at 8 p.m., at the Chemical Society, Burlington House, Piccadilly, W.1. "Continuous Distillation of Petroleum," by Mr. A. M. O'Brien.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Thursday, April 23, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2, "The Present Status of the Oil Shale Industry in Estonia," by Mr. P. N. Koggerman, M.Sc., F.I.C.

THE INSTITUTION OF MECHANICAL ENGINEERS: WESTERN BRANCH.—Thursday, April 23, at 7 p.m., at the Merchant Venturers' Technical College, Unity-street, Bristol. "Patents and Inventions," by Mr. E. S. Coward.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, April 23, at 8 p.m., at Denison House, 296, Vauxhall Bridge-road, S.W.1. "Timber Construction," by Mr. G. A. Gardner.

THE INSTITUTION OF WELDING ENGINEERS.—Thursday, April 23, at 8 p.m., at Caxton Hall, Westminster, S.W.1. "Overheating in Acetylene Generators," by Mr. Charles Bingham.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Friday, April 24, at 2.15 p.m., at the Technical Institute, Bell-street, Dundee. Discussion on "Justifiable Small Power Plants," with introductory remarks by Mr. A. B. Mallinson.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 24, at 6 p.m., at Storey's-gate, S.W.1. General Meeting. Reports to the Hardness Tests Research Committee. "The Effects of Adhesion between the Indenting Tool and the Material in Ball and Cone Indentation Hardness Tests," by Mr. G. A. Hankins, A.R.C.Sc. "Some Practical Aspects of the Scratch Test for Hardness," by Mr. G. A. Shires, M.Sc.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, April 24, at 6.30 p.m., at the Engineers' Club, Coventry-street, W.1. Lecture, "The Position of the Airship in Aerial Transport," by Commander C. D. Burney, C.M.G., M.P.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, April 24, at 7.15 p.m., at the University College, Singleton Park. Annual General Meeting.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, April 24, at 7.30 p.m., at the Literary and Philosophical Society, Newcastle-upon-Tyne. "Gas Turbines," by Mr. König.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, April 24, at 7.30 p.m., at the University, St. George's-square, Sheffield. Annual General Meeting. "Chromium Plating," by Mr. Byron Carr.

THE HULL ASSOCIATION OF ENGINEERS.—Saturday, April 25, at 7.15 p.m., at the Hull Technical College. Lecture, "Diesel Engines," by Professor A. L. Mellanby, M.Sc., M.I.Mech.E.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Little new business has been transacted during the past week and the outlook is anything but bright. More pits are to close down owing to the lack of demand and the impossibility of securing sufficient orders to keep the mines working regularly. Already pits have been closed down rendering some 40,000 men idle, some of whom have been able to find employment in other areas. The Palestine Railways are in the market for 25,000 tons of locomotive coal and the Newfoundland Government Railways want tenders for 65,000 tons of through coal. In connection with the latter inquiry it is understood that the lowest price submitted has been quoted for Scotch coals. At present best Admiralty large coal rules from 26*s.* to 26*s.* 6*d.* with Monmouthshires from 22*s.* 6*d.* to 24*s.*, and drys weak at 23*s.* 6*d.* to 25*s.* Best steam smalls range from 15*s.* 6*d.* to 16*s.*, with other sorts from 11*s.* up. Exports of coal as cargo foreign from South Wales last week totalled 252,290 tons compared with 550,050 tons in the preceding week, the heavy reduction being due to the intervention of the Easter holidays and the suspension of work at the docks on Good Friday and Easter Monday and Tuesday, while the miners were idle for the first three days of this week. Shipments to France totalled 69,530 tons, to Las Palmas 32,350 tons, and to Brazil 16,390 tons, while those from Cardiff amounted to 170,880 tons, at Newport to 33,200 tons, at Swansea to 31,950 tons, at Port Talbot to 15,760 tons, and at Llanelly to 1,150 tons.

Death of Dry Dock Manager.—Mr. Alfred Cox, M.I.N.A., general manager of the Cardiff Channel Dry Docks and Pontoon Company, Limited, and its subsidiary undertakings, died with tragic suddenness on Monday night. Deceased, who was 50 years of age after playing billiards at his house in the evening, had a sudden fit of coughing, and expired just after 10 o'clock. Though he had not been feeling well of late, and intended consulting a specialist in London on Tuesday last, Mr. Cox, who was President of the Bristol Channel Dry Dock Owners and Ship Repairers' Federation in 1922-23, had continued actively engaged in business.

Iron and Steel.—Exports of iron and steel goods in the past week from South Wales totalled 8,637 tons compared with 18,946 tons in the previous week. Shipments of tinplates and terneplates totalled 6,049 tons against 8,187 tons; blackplates and sheets, 952 tons against 1,947 tons; galvanised sheets, 1,203 tons against 4,994 tons; and other iron and steel goods, 433 tons against 3,791 tons.

LECTURES ON HEAT TREATMENT OF METALS AND ALLOYS.—A course of ten lectures upon the above subject, to be given by Mr. C. Coldron Smith, M.Sc., A.R.S.M., has been arranged at the Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C. 3. Commencing on the 22nd instant, the course will be held on Wednesday evenings, from 7 to 10 p.m. The lectures will be followed by demonstrations and practical work in the metallography and testing laboratories. The syllabus covers all heat treatment operations as applied to metals and alloys, both ferrous and non-ferrous and includes the theoretical consideration of the changes in properties produced in materials by annealing, hardening, tempering and case-hardening. The fee for those resident in the administrative County of London and in the County of Middlesex is 10 shillings. An extra charge is made in the case of those living outside the above boundaries.

1,500-KW. BRUSH-LJUNGSTRÖM TURBO-GENERATORS AT TUNBRIDGE WELLS.

CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, ENGINEERS, LOUGHBOROUGH.

(*For Description, see Page* 487.)

FIG. 1. VIEW OF TWO SETS.

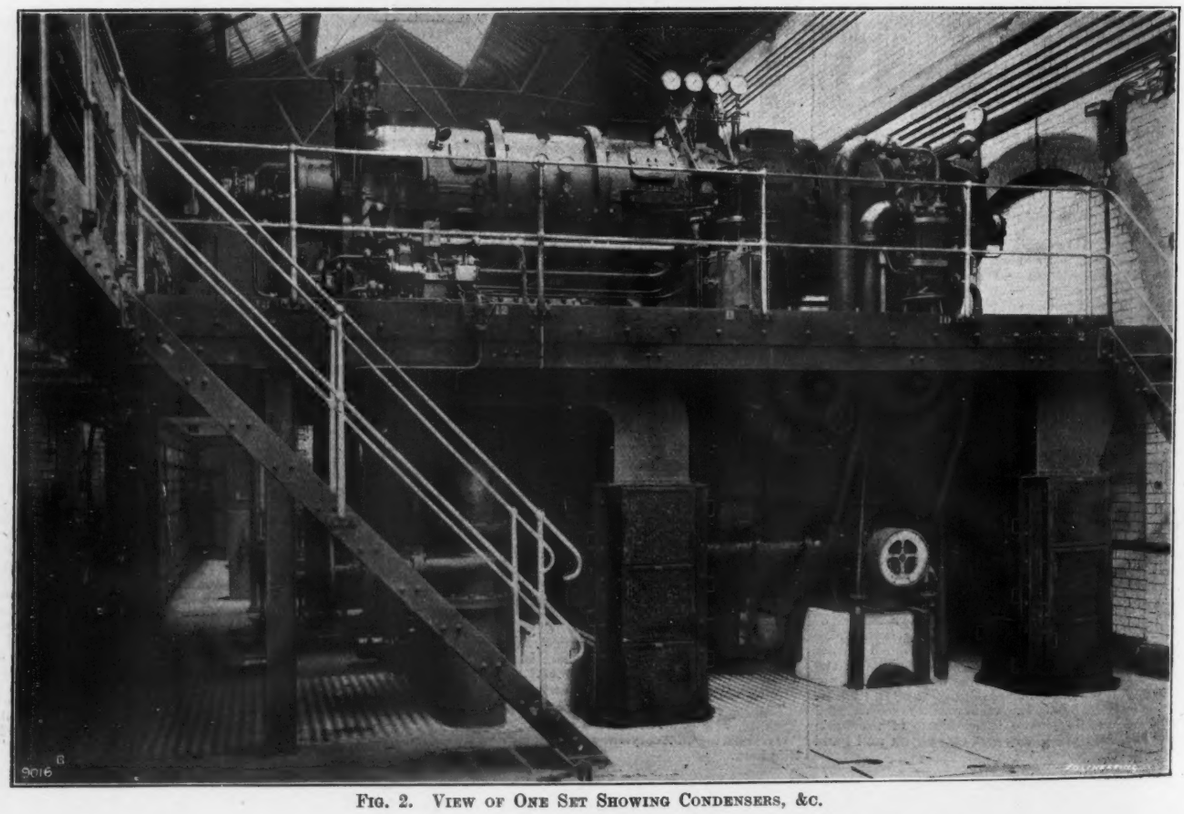


FIG. 2. VIEW OF ONE SET SHOWING CONDENSERS, &c.

THE REGULATION OF THE MURRAY RIVER; TORRUMBARRY LOCK.

(For Description, see Page 469.)

Fig. 26. PLAN OF LOCK

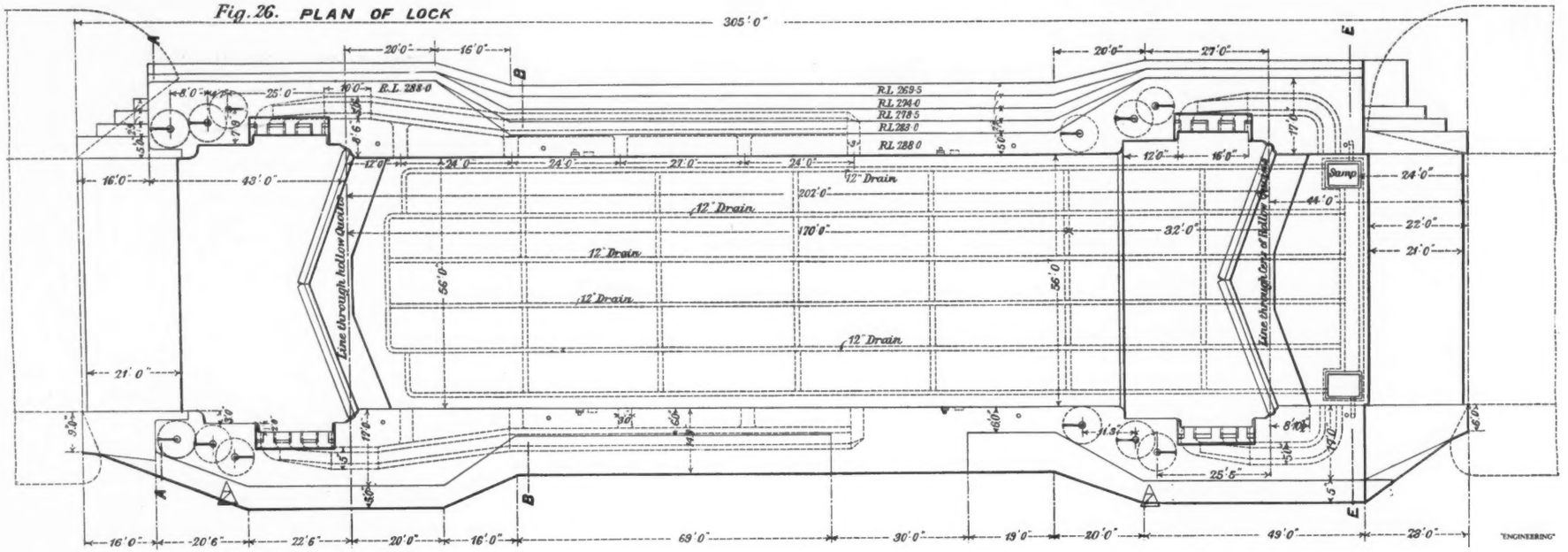


Fig 27. LONGITUDINAL SECTION ON CENTRE LINE

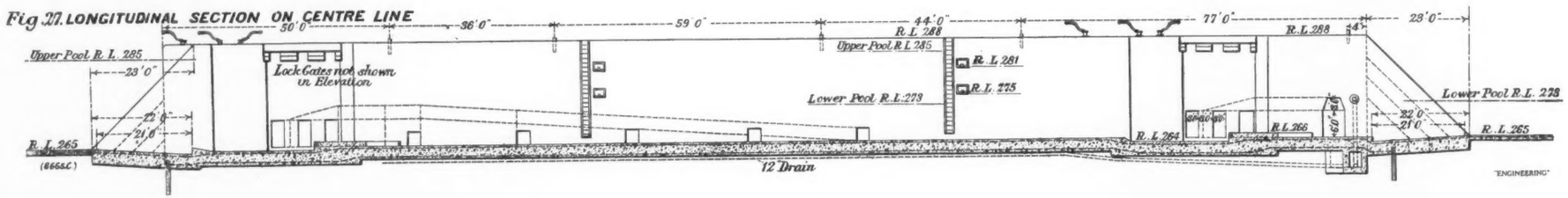


Fig. 28. CROSS SECTION A.A.

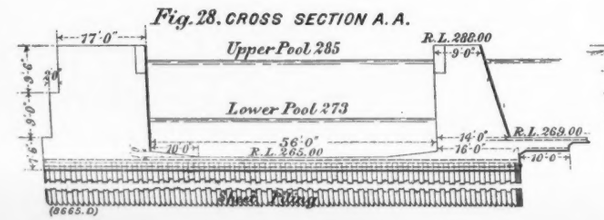


Fig. 29. CROSS SECTION B.B.

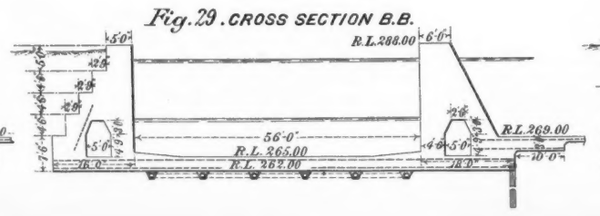


Fig. 30. CROSS SECTION E.E.

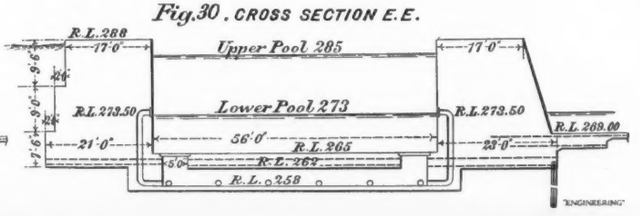
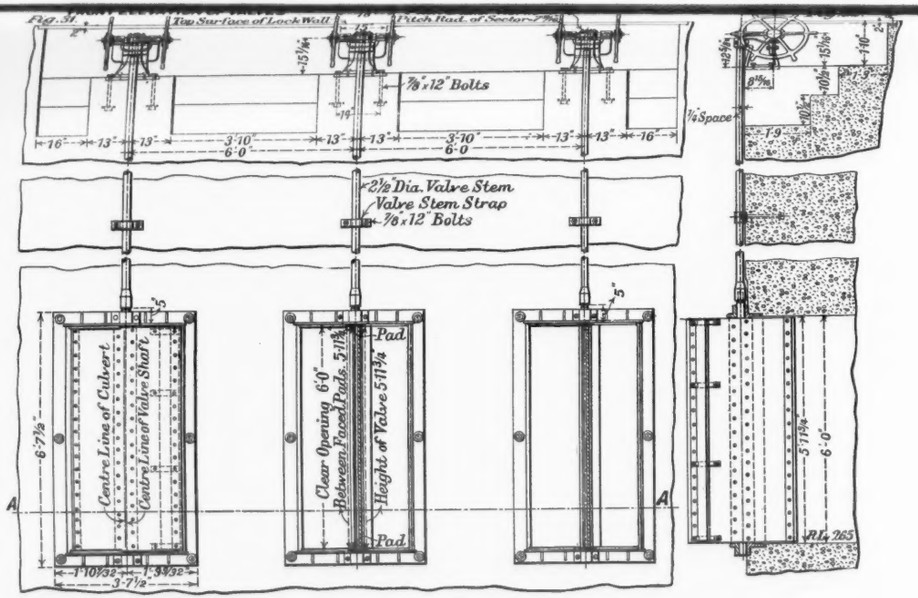


Fig. 37.



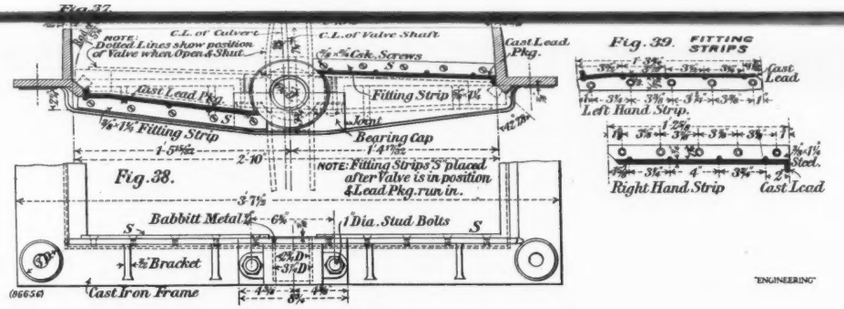


Fig. 39. FITTING STRIPS

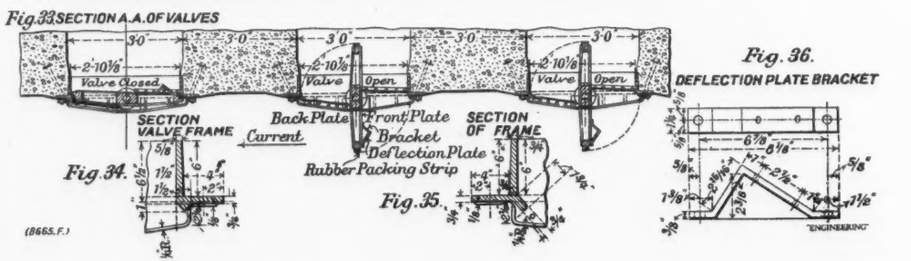


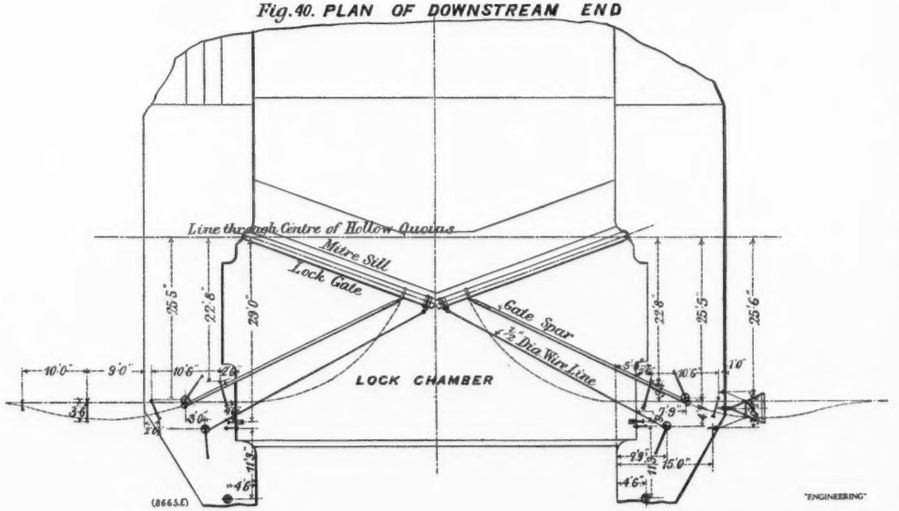
Fig. 33. SECTION A-A. OF VALVES

Fig. 34.

Fig. 35.

Fig. 36. DEFLECTION PLATE BRACKET

Fig. 40. PLAN OF DOWNSTREAM END



GATE SPAR SUPPORT

Fig. 41.

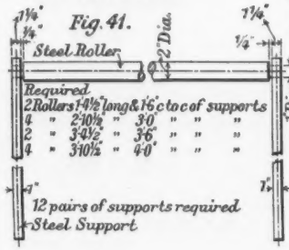

Steel Roller
2 Dia.
Required
2 Rollers 1'4½" long & 1'6" c to c of supports
4 " 2'10½" " 3'0" " " "
2 " 3'4½" " 3'6" " " "
4 " 3'10½" " 4'0" " " "
12 pairs of supports required
Steel Support
(B665.H.)

Fig. 42.

OREGON GATE SPAR

Fig. 43.

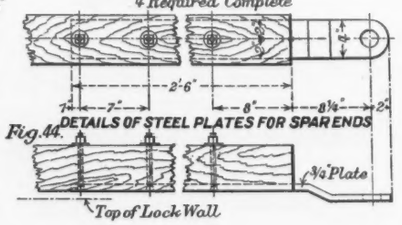


Fig. 44. DETAILS OF STEEL PLATES FOR SPAR ENDS

DETAILS OF ROLLER & BOLT FOR SPAR SUPPORT

Fig. 45.

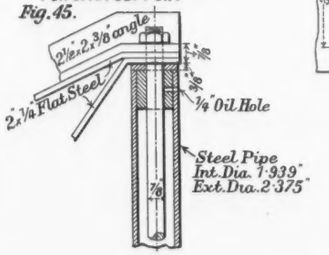
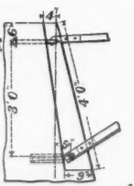
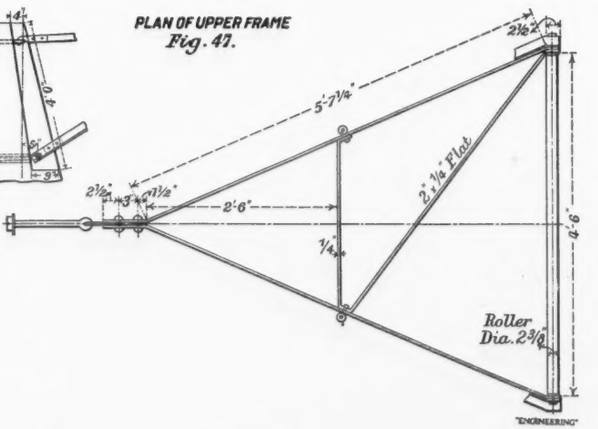


Fig. 46.



PLAN OF UPPER FRAME

Fig. 47.



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Two-Page Plate.—THE REGULATION OF THE MURRAY RIVER: TORRUMBARRY LOCK.

ENGINEERING.

FRIDAY, APRIL 17, 1925.

UNDISCOVERED COUNTRY.

IN his inaugural address to the Junior Institution of Engineers, of which he is the president, Dr. A. Russell drew attention to two considerations, which must, during the past few years, have impressed themselves upon many of the thoughtful amongst us. The first of these has reference to the steady and continuous decrease in the field open for adventure and discovery. The field for geographical discovery is rapidly being narrowed and at no distant date it will be impossible for the explorer to experience the thrill of the ancient mariners when they realised that they "were the first that ever burst into that silent sea." Similarly, in literature and art it seems improbable that either can make any novel and notable addition to human thought. The average standard of execution will, no doubt, be continuously raised, but the heights attained by the most eminent of the new comers, will be no more exalted than those reached by the very exceptional men to whom we owe the masterpieces of the past. It was, in fact, some consciousness of the hopelessness of surpassing the latter, which led, some few years ago in Italy and France, to the demand, formulated in some artistic circles, for the complete destruction of the work of those who had, it was held, exhausted the possibilities in sculpture, architecture, and literature, or speaking generally "qui ante nos nostra dixerunt." In some such way only, it was claimed, would it be possible to provide a fair field for a new generation of pioneers.

Extravagant as was the policy proposed by these rebels, there is unquestionably some ground for their dissatisfaction on realising how the pioneers of the past had left little for them to do, but follow in their footsteps. No doubt, we shall always have new settings of the well-worn literary and artistic themes, which, even although they add nothing really new to human thought, will please us in much the same way as a new performance of the famous ninth sonata of Beethoven. In literature and art, it does indeed seem as if we were approaching, or perhaps have already reached a time, when really new creative work will be impossible. To the ambitious young man it is as disappointing to find that his "original sayings" have been already anticipated, as it must have been, to Capt. Scott when, on his memorable journey to the South Pole, he found on arrival that some one had got there before him.

As matters stand, it would seem that in pure and applied science alone is there the prospect of an inexhaustible field for pioneering research, though some might claim similar possibilities for philosophy. As already suggested geographical exploration is yearly becoming more limited in its scope, as well as easier of execution, and it may well be that as facilities continue to improve the "attraction of the wild" may diminish. To-day, anyone can attain the summit of the Jungfrau, a fact which is strongly resented by many enthusiastic alpinists, who have, however, commonly based their objections to mountain railways on professedly artistic grounds. Such a position is wholly untenable since the railways in question are far too insignificant an object when seen on the flank of a mighty mountain to affect its beauty one way or another.

Were it not for the inexhaustibleness of science some similar resentment might well be felt towards the popularisation of wireless telegraphy and telephony. To-day a schoolboy, quite ignorant of the vast experimental and theoretical work which has been devoted to the subject, can assemble at the cost of a few shillings highly efficient wireless wave detectors, whereas in the pioneering experiments of Hertz the difficulty of detection was so great that some of the distinguished men to whom he exhibited his apparatus could not feel quite certain that they actually did see the microscopic spark which passed across the gap of his resonator.

We have here "commonising" with a vengeance, but, unlike the mountaineer, geographical explorer or *litterateur*, those who study nature find ever new worlds to conquer, and new undiscovered country in which real pioneering is still possible. Even here, however, disappointments are frequent. There have been many instances in which an inventor who in good faith has worked out and practicalised an idea he believed to be new, has ultimately found anticipations in the patent records. The same kind of thing occurs in pure science, and Dr. Russell mentioned the case of a mathematical friend who, when in the course of his work he came across a result which appeared new, of set purpose avoided for one week any attempt to establish its real novelty—so as to enjoy for at least that period the thrill of a first discoverer.

A second point to which Dr. Russell drew attention was the curious incuriousness of the general public of to-day, who seem to have largely lost the capacity for wonder which has been attributed to the ancient Greeks. To some extent, the changed attitude is due to a realisation on the part of the general public that one small section of the community has a greater understanding and knowledge of natural phenomena than is possessed by the average. Hence the latter fear that the expression to astonishment or wonder at such achievements as trans-oceanic telephony might be in effect a mere confession of ignorance. In the same way, the feats of a conjuror no longer give rise to any feeling of awe amongst his audience, since it is thoroughly realised by all, that even the most mystifying of such apparent performances has some simple explanation. It is assumed that this holds good also in the case of notable achievements in applied science, and it is felt safest, accordingly, to adopt a *nil admirari* attitude. When all were more or less equally ignorant, no such temptation existed; anything appeared possible, and the population marvelled at reported achievements, instead of criticising the evidence proffered in proof of their accomplishment.

In actual fact less is understood of natural phenomena than is commonly believed. The attempt to reduce all phenomena to matter in motion has signally failed; and the scientific investigator accordingly retains unimpaired that capacity for wonder which Dr. Russell attributes to the Ancient Greeks. As matters stand we have to be content to push particular theories merely

as far as they will go, and probably the hope of ultimate explanations of natural phenomena has been definitely abandoned by most physicists. This must necessarily be the case if, as some philosophers maintain, matter is never unassociated with mind, so that free will and spontaneity are, in the ultimate, involved in the union of two atoms of hydrogen with one of oxygen.

The great generalisations of the nineteenth century are now recognised as insecurely based. The conservation of mass—a doctrine which led to such magnificent results in the past—has had to be abandoned, and the fact that Mercury fails to keep time is now seen to be a consequence of the variation of its mass with its velocity of movement. Presumably the anomalies detected in the motion of the moon may have a similar source, but in any case it is now recognised that the poet, in stating that she was "constant to her time," did our satellite more than justice. Whether the doctrines of the conservation of energy and the conservation of momentum are any more firmly based than that of the conservation of mass still remains to be seen. In any case, a proof can only extend to the limits of observation, beyond which we cannot extrapolate without serious risk of error. In this connection it may perhaps be noted that it is now generally recognised that the second law of thermodynamics has no universal validity. As Tait pointed out years ago, Clausius' statement of this law must be violated in every mass of gas. Much attention has of late years been devoted to the study of these fluctuations in the constitution of a gas, and the possibility of a cubic foot of air separating itself spontaneously into its component gases, is recognised, though calculation shows that such an event could only occur once in trillions of years. Maxwell and Kelvin were, of course, much more cautious than Clausius in their formulation of this second law of thermodynamics and expressly excluded from its range, cases in which an intelligence might be able to seize on and sort out individual molecules.

Other difficulties in the understanding of nature were made evident by the experiments which led to Planck's atomisation of energy, a concept which it is extremely difficult to picture but which has led to very great advances in many departments of physics, and which must assuredly involve some substantial truth which will remain valid, even should very considerable modifications in detail ultimately prove necessary.

MOTOR VEHICLE BRAKES.

A VERY noticeable feature of the exhibits at the last Motor Exhibition at Olympia was the extremely wide variation in both the diameter and width of brake drums in the case of vehicles of approximately equal weight and power, and the only rational conclusion to be drawn was that many of the manufacturers had given little or no attention to the underlying considerations fixing these dimensions. The lack of anything approaching a consensus of opinion on brake proportions is probably in large part due to a difficulty in obtaining any authoritative information. An enormous number of books have been published which purport to cover motor vehicle design, but very few of these attempt to deal with fundamental principles; and the information which has actually been put at the disposal of designers on this and a number of kindred points is scanty in the extreme. Under these circumstances, it is very fortunate that a number of prominent men in the automobile industry have been willing to place their specialised knowledge freely at the disposal of designers. The Proceedings of the Institution of Automobile Engineers contain many valuable contributions of this type, and another has been added to the number by the paper on "Brakes for Motor Vehicles," read by Mr. G. W. Watson, on Tuesday of last week, before the Coventry Centre. The paper deals with the first principles of brake design, and covers the ground very fully without going into too much detail. Doubtless there will be dissentients to some of the minor conclusions reached by the Author, but upon the whole the paper should be of great service in eliminating much of the guess work which undoubtedly exists in connection with this subject. Space does not permit of our following Mr. Watson in any detail through the wide field which he covers, and we must confine our attention to a few points which stand out as being of particular interest.

Probably the most important quality of a car or lorry brake, and the one which is most frequently ignored, is that it should retain an approach to its original braking power for the longest possible time in the hands of the average user. In spite of what is frequently said about the educational value of a car from an engineering standpoint, we believe that the ordinary driver takes a minimum of interest in the car mechanism, and that if for example, he is obliged to delve into the greasy recesses of his chassis in order to maintain the efficiency of his brakes, he is sufficiently human to put off the job for the longest possible time. We incline to think that the mechanically operated, internal expanding, rear wheel brake is the most easily accessible for adjustment, requires a minimum of attention, and is likely to retain its efficiency for the longest time, and if this is so we probably have an explanation of the steady increase in popularity of this form of brake in recent years. The reputation of the transmission brake has suffered to some extent through bad design, as it is often made excessively small in diameter, with the result that it heats up very rapidly. In addition, in place of adequate provision being made for cooling, it is either pocketed or placed directly in the stream of hot air from the engine. Under these circumstances, it is likely to lose its efficiency rather rapidly, and is then condemned because it fails to pull up the vehicle quickly in an emergency. In addition to this, as it acts through the transmission, it is rarely as smooth in action as the rear wheel brake. The introduction of front wheel brakes has led to the recrudescence of a number of types which had previously been abandoned as unsatisfactory, and amongst these we venture to place the hydraulic brake which Mr. Watson appears inclined to consider favourably. We feel that the possibility of leakage is much greater than the remote possibility to which he refers, at any rate when the maintenance of the brake is in the hands of a totally ignorant driver. In this connection, it is somewhat difficult to see the marked difference between an hydraulic braking system on the one hand, and water-cooling of the brake drum on the other, which leads Mr. Watson to unhestitatingly condemn the latter on the grounds that the water tank is usually empty, or the pipe leaking so badly that all the water drops on to the road, and none on to the drum.

The large number of brakes on the market which are subject to squeaking is a matter of surprise, as this is a clear indication of defective design. Mr. Watson gives the cause of squeaking as either due to localised excessive pressure resulting from high points on the lining, or general excessive pressure leading to the separation of metallic particles from the bonded asbestos lining when the latter contains a metallic element. He states that the trouble can be entirely overcome in the latter case by making the drums larger in diameter, but we believe that we are correct in stating that squeaking may also be due to vibration in the drum itself, due to excessive thinness of the rim.

In dealing with the effort necessary to operate the brakes, the author suggests that this should not exceed 40 lb. for a car which may be driven by a lady, or 75 to 80 lb. for a commercial vehicle in which the driver, usually a man, is more favourably seated for exerting his maximum hand and arm effort. This means that in many cases some auxiliary method of increasing the force exerted by the driver becomes necessary, and this is generally performed by means of a servo-motor, although a compressed air or hydraulic system is occasionally employed as an alternative. It would appear that some such mechanical system as that designed by Messrs. J. Stone and Co., Limited, for railway wagon work deserves consideration in this direction, as by this means a high velocity ratio can be obtained without the uncertainty in action associated with some forms of servo system. This brake in fact, appears to offer a solution to the problem postulated by Mr. Watson when he states that what is required is the development of a device which will always be under direct control of the driver, will give a quick action for taking up all clearance between pins and holes, shoes and drums, &c., and having done that, automatically and almost instantaneously provide increased velocity ratio between the hand and shoe.

LONDON STREETS AND LONDON TRAFFIC.

FOR years past there have been periodical complaints, concerning the inconvenience caused by repairs to road surfaces or to sewers, electric, gas or water mains. At times no doubt the writers have been more vehement than reasonable. Unfortunately, pavements will persist in wearing out, and the installations of pipes and cables below surface are not invulnerable to various causes of decay. Making all allowance, however, for much ill-informed criticism, the disturbance caused has at times been much more serious than was necessary. Thus, in a circular recently issued by the Ministry of Transport it is noted that two years ago Oxford-street and the Strand were "up" simultaneously, thus closing the two main east and west arteries; and, again, last year, whilst Parliament-street was closed for repairs, street works were also started in Horse Guard's Avenue, thus greatly increasing the inconvenience caused.

Under the new London Traffic Act the Ministry was granted powers to regulate the execution of all metropolitan road work, which may involve the closing to traffic of more than one-third of the thoroughfare. The selection of the streets over which these powers were to be exercised, was left to the Ministry, who for the present will exercise this control only over the more important streets within a radius of 2½ to 3 miles of Charing Cross, and on certain trunk roads feeding the central area. Some special points of congestion in the outer points of the London traffic area will also be controlled. The Ministry have aimed at ensuring that where a street is closed for traffic, a reasonable alternative route shall remain open. In drawing up programmes for street works, account is to be taken of the dates of important public events, such as Derby day and the like, when there is exceptional traffic along certain thoroughfares. Applications to open up streets for any purpose must receive the assent of the Ministry, save in cases of emergency. In this way it is hoped that a reasonable measure of co-operation will be established between the various bodies interested in street works. The Ministry express appreciation of the helpful manner in which their proposals have been met by those concerned.

Regulations have also been issued setting forth the restrictions on omnibus traffic as revised for the summer services of the Wembley Exhibition. The restrictions will be entirely removed on Sundays, Good Friday and the day following, and on Bank Holidays generally, and in certain cases will also cease to apply on Saturday afternoons. Services to the Wembley Exhibition are also to receive special consideration. The policy of having any restrictions at all is, perhaps, open to question, but assuming that the natural development of traffic is to be regulated, it is at least satisfactory that the control is in the hands of so capable a body as the Ministry of Transport, which, so far, has been kept "out of politics."

WATER-TUBE BOILERS.—The Vickers-Spearing Boiler Company, Limited, of 20, Kingsway, London, W.C. 2, will be pleased to lend for the purpose of illustrating lectures a set of lantern slides of various types of water-tube boilers and chain-grate stokers.

THE ROYAL MICROSCOPICAL SOCIETY.—In response to an invitation extended by the University of Sheffield the Civic Authorities, the Master Cutler, and the Research Associations to the Royal Microscopical Society of 20, Hanover-square, London, W. 1, to hold a conference in Sheffield, it has been decided that a meeting will take place there on April 20, and following days. All inquiries regarding the programme of the meeting and travelling facilities, &c., should be addressed to the Hon. Secretaries of the Society, Mr. J. E. Barnard and Mr. James A. Murray, at the above address.

THE SHIPBUILDING INDUSTRY.

IN the shipbuilding returns for the quarter ended March 31, 1925, just issued by Lloyd's Register of Shipping the figures, compared with those for the preceding quarter, indicate a continuance of the decline we have previously had to record. The work in hand has decreased by 132,000 tons to 1,165,468 tons for the total tonnage under construction in Great Britain and Ireland. During the year previous to March, 1925, however, the tonnage on which work was suspended was reduced from 101,000 tons to 74,000 tons. Further, a slight increase is shown in the tonnage commenced during the last quarter, 202,352 tons, compared with 194,594 tons in the final quarter of 1924. The tonnage launched during the quarter—339,120 tons—is 13,509 tons lower than that for the preceding three months. The current tonnage being built includes 280 vessels, of which 213, with a tonnage of 800,848, are steamers and 54, with a tonnage of 359,920, are motorships. Sailing vessels building number 13 and have a combined tonnage of 4,700. The proportion of motor tonnage to steam tonnage of ships building continues to increase, and now amounts to approximately 45 per cent. of it.

Merchant tonnage to the amount of 1,231,442 tons is being constructed abroad, comprised in 396 vessels. This is an increase of about 58,000 tons over the figure returned at the end of December last, which in turn was 61,000 greater than that returned at the end of September, 1924. Thus, we are witnessing a steady fall in the proportion of the world tonnage constructed in this country. The position with regard to foreign shipbuilding, nevertheless, cannot be said to show much improvement, for, whilst the new tonnage launched abroad during the last quarter totalled 267,101 tons, an increase of 72,745 tons over the corresponding figure of the previous period, the new tonnage laid down—namely, 192,618 tons—showed a decrease of 97,983 tons compared with the previous three months. Germany is continuing to build almost one-third of the total tonnage under construction abroad, but it remains to be seen if the prices at which orders have been secured will prove sufficiently profitable to justify a continuance of the keen rates tendered by firms in that country.

To the total of 1,231,442 tons of merchant shipping under construction abroad during the past quarter, France contributed 187,437 tons, comprised in 37 vessels; Italy 164,023 tons, with 36 vessels; and Holland 119,908 tons, with 37 vessels. The United States had under construction 38 vessels of 81,728 tons, registering an increase of over 23,000 tons over the figure returned for the preceding three months. An examination of the figures contained in the returns emphasises the need for a drastic policy of building cost reduction if any important improvement is to be attained.

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W. 1, announces that the Chief Electrical Engineer's Branch of the New South Wales Government Railways and Tramways are inviting tenders, until noon on July 8, 1925, for the manufacture, supply, and erection of two coal elevators and the maintenance of the entire equipment for a period of twelve calendar months after it has been taken over for regular service.—The Chefoo Harbour Improvement Commission invite tenders for the supply and delivery of two steel-frame buildings. Sealed offers will be received at Chefoo, China, until May 31, 1925. Further information regarding these calls for tenders may be had on application to the Department of Overseas Trade.

THE EVOLUTION OF SCIENTIFIC INSTRUMENTS: ERRATA.—Professor E. N. da C. Andrade draws attention to a few inaccurate statements in our report of his lectures (see ENGINEERING, April 3, page 407). As regards the open-sight instruments, Hooke pointed out that, owing to the limited resolving power of the eye, the best that could be hoped for was an accuracy of half a minute. The thermometers of the Accademia del Cimento had not in general spiral stems (not bulbs). The spiral stem to which we made reference and which Professor Andrade showed, was a *tour de force*. "Thomas Digges did not speak of his father having used his telescope to observe stars, but only celestial objects, a curious point, because the first Dutch telescope makers apparently never thought of turning their instruments on to celestial objects." The book referred to was printed in the "black-letter type" of the period, 1571, which differs little from modern German type.

THE JOHORE CAUSEWAY.*

By DONALD PATERSON, Assoc.M.Inst.C.E.

THE paper describes the design and construction of the causeway carrying a double line of metre-gauge railway and a road over the Johore Strait, joining Singapore island with the mainland. The depth of water in the strait is generally 6 fathoms. The western entrance, however, is shallow, and through navigation is only possible for craft of shallow draught.

The chief factors determining the choice of a causeway were: the presence of large granite boulders in the stiff clay forming the bed of the strait, which would have rendered the founding of bridge-piers difficult; the cost of, and delay in obtaining, steelwork during the war; the low maintenance cost of a rubble causeway; and the availability of ample quantities of suitable granite.

The author describes the complete series of tidal observations, commenced in 1917, to determine the probable effect of the causeway on the tides and the provision necessary for the passage of craft. It was found that a lock equipped for dealing with a head of water on either side would be necessary. The tidal range at springs was 10 ft. 3 in.

Description of Works.—The causeway is 3,465 ft. long, the average depth of water is 47 ft. below L.W.O.S.T., and the top width at formation level is 60 ft. The bank below 15 ft. below L.W.O.S.T. is of granite rubble of all sizes up to 5 tons, finished off to slopes of 1½ to 1. Above this level the bank was coated with 10 ft. of heavy rubble—10 cwt. to 5 tons—at a slope of 2 to 1, finished off at the level of 4 ft. above L.W.O.S.T. with a berm. Concrete blocks form the toe of the granite randon rubble pitching, 1 ft. 6 in. deep, laid as the 1½-to-1 side-slopes of the superstructure. The total quantity of rubble in the work is 1,599,900 cub. yards.

Ten circular 5-ft. culverts pass through the Johore end of the causeway, in proximity to the lock. The overall length of the lock, including the two wing walls, is 510 ft., the dock being 170 ft. long between gates, 45 ft. wide, reducing to 32 ft. at the gates. There is 10 ft. depth over the sills at low water. The walls, gate-platforms, inverts, and aprons are of 6-to-1 mass concrete, and the wing walls are of 7-to-1 mixture, all having 1 ft. of 4-to-1 facing. The major portion of the lock and the whole of the west wing wall are founded on ballow (native hardwood) piles driven into soft clay. The east wing wall is founded directly on hard red clay.

The road and railway tracks are carried over the lock by a steel rolling-lift bridge, 57 ft. wide, with a clear span of 32 ft. A subway, 11 ft. 6 in. wide by 8 ft. high, passes under the lock, for the accommodation of water mains.

Construction.—The contract was let in June, 1919. Of the rubble used on the work 80 per cent. came from Pulau Ubin, an island 16 miles distant by sea from the work. Transport was by 300-ton hopper barges and lighters, towed by sea-going tugs. The quarry had been first opened up in 1907, but had been disused for several years, necessitating much preliminary work before a satisfactory output could be obtained.

It was decided to complete the roadway side of the causeway first, and to provide a temporary railway track thereon, since the other side of the causeway was accessible to barges coming directly from the quarry. The lower portion of the causeway was deposited from hopper barges up to a level of 3 ft. below L.W.O.S.T. Above this level the bank was built by 5-ton steam derrick cranes, mounted on short lengths of the causeway deposited by 12-ton floating cranes. Early in 1922 a quarry in Singapore was opened, and stone was brought direct by rail and tipped to the work.

Construction proceeded from both sides of the straits until July, 1922, when the width of the channel was reduced to 1,300 ft. A layer of rubble was then deposited on the bottom of the gap, as a defence against scour. The gap having been reduced to 1,000 ft., the rubble was built up to as near low water level as possible by hopper barges. The final closure was made by means of a temporary bridge, 200 ft. long, to which pilot banks were run out from each end of the completed superstructure, stone being tipped from the bridge. The temporary railway was opened in October, 1923—a year in advance of the contract date of completion.

The lock was commenced at the end of 1919, construction being carried out partly in the dry and partly within a steel coffer-dam, and was opened in June, 1923.

The effect of the causeway on the tides in the straits has been observed by electrically-synchronised recording tide-gauges installed on either side of the causeway. Although the range of the tides has been increased the sequence of changes of head from one end of the straits to the other has not been greatly altered.

A careful series of current observations has been carried out. Before the work the maximum velocity recorded on the site was 193 ft. per min. While the work was in progress the highest observed velocity was 820 ft. per minute, and still higher velocities occurred, but were not capable of record owing to turbulence. Velocities of less than 500 ft. per minute were in agreement with theoretical prediction, but for higher values the actual velocities were considerably in excess of the theoretical.

* Abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, April 21, 1925.

MARINE OIL-ENGINE TRIALS.

WE reported earlier in ENGINEERING the discussions on the Second Report of the Marine Oil-Engine Trials Committee at a meeting of the Institution of Mechanical Engineers (see issue of March 27, 1925, page 391), and also at the Institution of Naval Architects (see issue of April 10, 1925, page 445). In addition to these discussions others have been held in Glasgow and Liverpool. Abstracts of the discussions at these later meetings are given below. An abstract of the Report appeared in our issues of March 27 and April 3.

At the Glasgow Branch meeting of the Institution of Mechanical Engineers on March 26, Dr. A. L. Mellanby, the Chairman of the Branch, presided, and in his introductory remarks called attention to the fact that in the trials conducted on steam-driven vessels in 1889, the first engine studied was that for the S.S. Meteor, of 2,000 i.h.p. An indication of the advance made since then was shown by the overall efficiencies of this engine and those of the Dolius. The 10 per cent. value for the Meteor had to be compared with 40 per cent. for the Dolius. Great, however, as this charge was, the increase of efficiency had not kept up with the increasing costs of fuel. For the trials of the Meteor the fuel charge was 7*s.* 6*d.* per ton, but for the Dolius was ten to fifteen times as much.

It was a correct line for the Committee to take, to give merely a record of the various trials without comment, but as individuals they had the right to investigate the relationship of the results. The attainments in regard to the fuel consumption of the Dolius were something of which the builders should feel proud. Manœuvring qualities had also been shown which must remove the suspicion from the minds of some engineers regarding the flexibility of operation of this type of engine. The torque values derived from the torsionmeter, the horse-power and the fuel readings were not consistent, and in his (Dr. Mellanby's) opinion the torsionmeter readings were quite wrong, since if they were correct both ship and engines must possess remarkable characteristics. It was unfortunate that in the two sets of trials so far reported on, the labour and expense devoted to the provision and use of torque and thrust meters should have produced so little in the way of results. He regretted, in concluding, that in the list of acknowledgments in the report no proper appreciation was expressed to Mr. John S. Brown for his valuable services during the trials.

Mr. Archibald Rennie referred first to the thermal efficiency deduced from the trials, and said that it did not do full justice to the Still system, as the power developed by the turbine was not credited to the main engines, although it was obtained from steam generated by waste heat from the combustion side. Were this power included the thermal efficiency came out at 41·2 per cent. when calculated on the indicated horse-power basis and 39·2 per cent. on the brake horse-power basis. The radiation losses on both the steam side and the combustion side were high, amounting to nearly 10 per cent., but an explanation might be found in the fact that the tests were carried out in a large airy shop in the beginning of winter, and the laggings were necessarily imperfect. The blower supplying the scavenging air was twice the size necessary, and its efficiency was therefore small. Had the blower been of suitable size, it was estimated that 56 h.p. would have been required for its drive. As the turbine gave 51·5 h.p., only the difference need be made up by the motor and charged against the engine. Were this correction made, the net brake thermal efficiency would be 36·8 per cent. instead of 35·4 per cent. The steam consumption of the main engines—21·2 lb. per hour per indicated horse-power—appeared to be high, but were the power developed by the blower turbine included the consumption fell to 14·8 lb. per hour per indicated horse-power—quite a reasonable figure. Were the total indicated horse-power to include the blower-turbine power the figure would reach 1,457, and this was obtained with a fuel consumption of 0·308 lb. per hour as compared with the figure 0·322 given in the Report.

The diameter of the cylinder of the Scott-Still engine was fixed by the oil side, and consequently the only way to regulate the amount of steam taken by the engine was to make the cut-off very early, or

throttle the steam passing into the engine. The cut-off of the engine tested by the Committee was arranged to take place at about 9 per cent. of the stroke. In practice even this was not early enough to enable the stop valve to be opened fully, and consequently it was necessary to throttle the supply of steam.

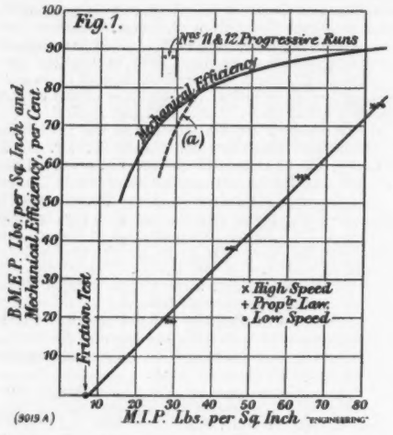
Mr. John S. Brown, of the research staff of the British Marine Oil Engine Manufacturers' Association, and chief observer in the trials, stated that the technical nature of the Report in no way hid the outstanding commercial economy of the Scott-Still engine, while the manœuvring qualities indicated the desirability of a mechanical recorder, if tests were ever made on an engine, which would improve on the results so far attained. He then proceeded to make deductions from some of the data submitted, the selected items being such as showed the necessity for explanatory remarks from the Committee. Whatever, however, reflected on a few of the 2,000 tabular entries in the Report could only have the effect of adding to the standing of the remainder. In the Report it was stated that the exhaust pyrometers required to have different corrections applied for each position. This was a common fault of pyrometers, and as the results were of vital importance at sea, for checking the tuning of the engine, it was hoped that the instrument makers would be impressed with the necessity of eliminating the causes of these variations in future types. The correcting calibration hindered the use of discretion in the suppression of readings which appeared doubtful. Such suppression had been carried out for one location on the engine. The position created by the treatment of some of these results left an equal reflection on the accuracy of those remaining. Some consolation was, however, to be derived from the experience that exhaust temperature observations were always in error. The deleted figures, which appeared to be low, might possibly have been obtained from a pyrometer which was working well. The deletion of certain entries for water loss also reflected on the figures which were allowed to remain. The irregularities were extraordinary. On the day occupied on the full-load tests there was a period in the forenoon when an additional, and presumably individual, source of steam loss was proceeding at a rate corresponding to that from a ¼-in. hole in the main steam pipe. Surely anything of this nature would come under notice, or involve an alternative view that the water loss figures were open to question. Should this be the case, it was unfortunate that such results should be used in dealing with the heat balance.

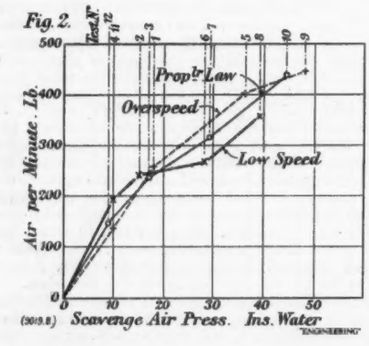
In Fig. 19 of the Report (see ENGINEERING, March 27, 1925, the suppression of the major number of the test points conveyed an erroneous impression of the accuracy obtainable from indicator cards. There was no evidence to support the bend on the curve in that diagram. Evidence was available that the indicators could be depended on to within 3 lb. per square inch mean indicated pressure. The mechanical efficiency curve derived from Figs. 18 and 19 in the Report was shown in Fig. 1 below, and here the point from the steam friction tests also was shown. It would be observed how different from that in the Report was the new curve for mechanical efficiency, and this should occasion the revision of the shaft horse-power in the sea trials, particularly in tests 11 and 12.

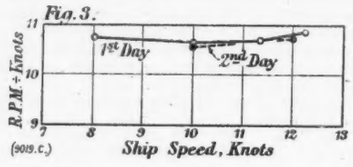
The exhaust gas analyses given were not yet free from "adjusted" figures, arising from defective sampling tubes, but the tests in question were at low powers and were consequently of little moment. On some undefined basis the analyses had all been judged to be admissible. One basis that might have been used was the plotting of the quantity of air flowing through the engine, as derived from the analyses, against the pressure causing the flow. The resulting graphs were shown in Fig. 2. The curves showed an entire absence of uniformity in the connection between the different test series and would infer the presence of certain experimental errors. These irregularities would be carried forward to the subsequent calculations in the heat balance. The "adjusted" samples at half-load appeared to have grouped themselves within a narrow cluster, and while this might be covered by the irregularities, it would be of service to have the original analyses available.

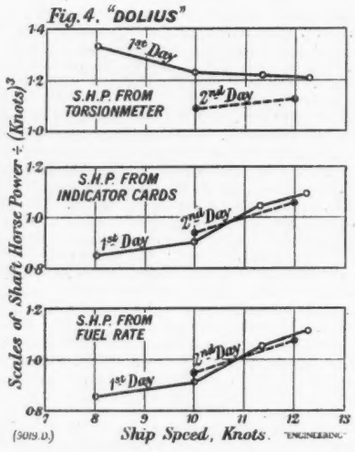
The present position regarding torque derivations was very unsatisfactory. A series of values, each of supposed equal authority, were available, derived from the torsionmeter, the indicator cards, and from the rate of using fuel. The inconsistency between them prevented any of the results being accepted. It was therefore necessary to analyse the performance of the Dolius to find a sound basis for evaluating the reliability of the various records. At no point in the Report had the progressive trial "fuel rate" torque on both shafts been established. For the analysis of the ship's performance it was proposed to accept as the authority Mr. G. S. Baker's book on "Ship Form Resistance and Screw Propulsion," in which, in Chapter XXIV, the examination of trial data was considered in detail. On page 232 of this book it was laid down that two separate curves were to be developed from the observations of the shaft horse-power, the revolutions per minute and ship speed in knots. The characteristics which such curves showed were there described and the discrepancies which might exist were mentioned. Working on this basis the first curve for the Dolius was shown in Fig. 3. In this the revolutions per minute divided by the ship speed in knots was plotted to a base of ship speed, and the horizontal nature of the resulting graph was in accordance with the requirements specified for such a curve, and thus the records of revolutions per minute of the engine and speed of the ship were completely acceptable. In considering another set of characteristic curves, showing the shaft horse-power plotted against the cube of the speed of the ship in knots, it was found to be necessary to draw separate curves. These were given in Fig. 4 for which the shaft horse-power had been calculated directly from the torque and revolutions per minute. The slight difference in the vertical scales was not of moment, as it was only the form of the curves which was under review, but the scattered locations of the points derived from the torsionmeter readings was an immediate reflection on their accuracy and made it necessary to separate the records of each day. The characteristic which these graphs were required to show was a gradual upward slope at the higher speeds. As the torsionmeter results were not only scattered into two groups but gave a false slope for the curve for the progressive trial series, it was impossible to accept them. From the indicator cards and from the fuel used similar curves were derived, and both complied with the required form and were in good agreement, and thus there was every reason to regard them as satisfactory.

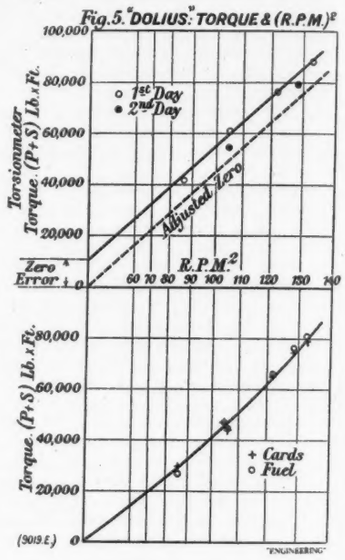
It was of interest to conduct a search for the possible source of error in the torsionmeter, and for this purpose Fig. 5 had been developed from the relationship of torque to the square of the revolutions per minute. The proportional variation of the two quantities plotted was not recognised as completely accurate, as was commented on in the Sycamore Trial Report, but the curves from both the fuel and the indicator cards showed little departure from a straight line relationship, and further, the graph passed through the origin. Again, inconsistencies were shown between the records of the torsionmeter on different days, and in this instance these could only be explained by a change in the zero. Further, it would be quite redundant in the case of the first-day results to join the low-speed point to the origin, as the inflection of the curve would be quite inconsistent with any theoretical consideration. As an alternative, the first-day series of points were joined by a straight line continued to the torque axis, which showed a zero error of 10,000 lb.-ft. Might it be asked, he said, if this torque was really required to hold the ship at rest? The widely-spaced points which fixed this line gave every chance of obtaining it with reasonable accuracy. The series of torsionmeter records could now be amended to the adjusted curve at the original revolutions per minute. In this way a series of torsionmeter figures had been arrived

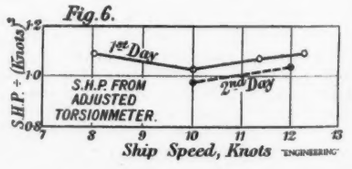












at which were consistent from day to day and which complied with the requirements that the torque was zero at zero speed, but they were recognised as slightly approximate in their straight-line relationship. From these amended values, Fig. 6 has been prepared to recast the first portion of Fig. 4, and it was of interest to note that the curve now rose at the higher speeds and thus complied with the requirements. The numerical values obtained were also in close agreement with those derived from the indicator cards and the fuel rate. This speculative procedure had given an attractive solution of the disagreement of the torque records, but involved a reflection on the zero setting of the torsionmeter. It was quite unsatisfactory merely to clamp the apparatus on the shaft and take the zero at the position that the parts then occupied. Firstly, the shaft might not be completely relieved from the twist of its last movement, and, secondly, the slight friction between the torsionmeter members introduced an appreciable effect. There was no indication in the Report of the procedure adopted. The second of the factors mentioned as possible sources of error might continue to cast suspicion on the light sheet-iron construction, which formed the backbone of the instrument.

Mr. Blacklock made a comparison between some of the results of the trials of the Sycamore and the Dolius, which brought out the high thermal efficiency of the Scott-Still engines, but showed the necessity for a greater number of men to operate them. The speed of the Sycamore engines might be too high. In manœuvring, an order could be executed in 7 seconds on the Dolius, compared with 13 seconds on the Sycamore. The time, however, of the latter could be reduced about 50 per cent. with hot bulb engines. In the Dolius, for 455·1 lb. of oil per hour a mean pressure of 76·4 lb. per square inch was obtained, while 537·4 lb. of oil per hour were needed for the auxiliary burners under the boilers to obtain a mean effective pressure, referred to the combustion cylinder, of 16·3 lb. per square inch. Actually, the results were worse than this, for some of the steam power was obtained from waste heat, which meant that 3·2 lb. of oil were used per indicated horse-power per hour on the steam side, instead of 0·34 lb. per indicated horse-power hour.

Mr. A. I. Nicholson commented on the disparity between the mean effective pressure (17 lb. per square inch) at no load in Fig. 19 of the Report and the results obtained when running light on steam of 6·7 lb. per square inch. It looked as though the higher value was not quite fair to the engine. Consideration of the engines of the two vessels, Dolius and Sycamore, showed that they compared quite well in respect of power losses due to friction per working stroke.

Mr. James Richardson said that the weight of the machinery of the Sycamore was higher than the average for the type of engine. A reduction of 200 tons could have been made if it had not been that steam auxiliaries were used, as well as some other special requirements for the trade for which the ship was built. The minimum speed of running of the Sycamore engines compared favourably with the minimum speed of running of those of the Dolius, when no steam was used. When the operator had experience, speeds of less than 30 r.p.m. could be maintained continuously with the type of engines used on the Sycamore.

At the Liverpool meeting on Friday, March 27, which was a joint one of the North-Western Branch of the Institution of Mechanical Engineers and the Liverpool Engineering Society, Mr. S. B. Freeman presented the report.

Professor W. H. Watkinson, in testifying to the valuable work done by the Marine Oil Trials Committee, said, however, it was seldom, if ever, justifiable to exclude observed data from a report. It was evident that a thermometer in the exhaust pipe of a two-stroke cycle engine would always read lower than corresponded to the average value of the whole exhaust, due to the influence of cool stagnant air left in the pipe after the completion of the scavenging. Stratification in the gas flow in a pipe might lead to erroneous analyses of the exhaust gases. It was unfortunate that the supply of air to the engine was not measured by a direct method. No attempt appeared to have been made to determine the ratio of air to oil for the working part of the stroke, and no light spring diagrams were given. He then proceeded to calculate the weight of scavenge air and compared it with that used in the cycle, and showed that it was in excess of what was usual in two-cycle engines. Unless he had misunderstood the statements regarding the correction for oil leakage at the three-way cocks in the fuel measurements he thought the fuel determinations were open to criticism in the same way as the analyses.

Mr. Dall said that as only 8 per cent. to 11 per cent. of the power generated on the oil side was obtained from the steam side in the Dolius engines, there did not seem to be much saving with them over the ordinary types of engines. Another speaker pointed out that they had no record of the cost at which this small increase was obtained, and this might become a considerable item when it came to be necessary to overhaul the engine. Wear and tear of piston rods, valves and other components, which needed renewals, might detract considerably from the amount reckoned for the gain in thermal efficiency.

Mr. Purvis thought there was a marked contrast in character between the thrust curve and that from the torsionmeter. It would have been better had two thrust indicators been fitted, one on each shaft, so that the total thrust for the ship could have been obtained.

Professor Scholes called attention to the disparity between the sums of the latent heat deduced from the steam generated and the sensible heat, and that given as the total heat recovered. From the temperatures stated it was apparent that the water drum of the main regenerator was not serving any useful purpose in giving heat to the water. Most of the heat was obtained at the feed-water cylinder. These conditions indicated the possibility of simplification of the plant. When the power was increased by the use of the main regenerator as a boiler, the extra power was obtained by the use of a very disproportionate amount of oil.

Mr. Davies called attention to the fact that three of the frictional horse-powers, obtained under differing load and speed conditions of running, were given as being the same, namely, 88 h.p.

Mr. Kearton was surprised that the scavenge air was not measured directly. It was stated in the Report that the thermal efficiency of the standard of comparison had been taken as 0·50. Taking the data for Test 10 in Table XIII (see ENGINEERING, March 27, 1925, page 400), and allowing for the variation in specific heat, the thermal efficiency of the ideal cycle, working under the same conditions, was not 50 per cent. but 59 per cent., and the figure given for the efficiency ratio should be modified accordingly. For Test 10 this value was 0·688 and not 0·81 as given in the Table. Taking a broad view of the results, it seemed that the gain in power from the steam side was hardly worth all the complication.

Mr. Freeman then closed the proceedings by summing up the points brought out in the discussion. They had, he said, expected to get 14 per cent. of the power of the engine back in the steam generated; no more than that was attempted, and no more was achieved.

EXTENSIONS AT TUNBRIDGE WELLS POWER STATION.

WHEN the public supply of electricity was commenced in Tunbridge Wells about 30 years ago, considerable difference of opinion existed, as to the most suitable frequency for alternating currents and for some reason, which is not now particularly obvious, the frequency adopted was 67·5 cycles. Single-phase current was generated at 2,000 volts, transformed down and distributed from sub-stations at 220 volts for public and private lighting. The power station was constructed in Stanley-road near the railway goods station, and the original equipment consisted of two 100-h.p. and one 50-h.p. Willans-Johnson and Phillips' sets, supplied with steam from two water-tube boilers rated at 124 h.p. each.

The generating plant and boiler equipment were considerably increased in 1909, the additions including a further 100-h.p. Willans set, a 550-h.p. Ferranti engine and alternator, a 500-h.p. Willans-Ferranti set, and a 700-h.p. Westinghouse-Parsons turbo-alternator. The total capacity then amounted to 2,150 h.p., and steam was supplied by five Babcock and Wilcox boilers and two Lancashire boilers. A 300-kw. British Thomson-Houston turbo-alternator was put down in 1915, and a further addition was made in 1921–22, when a 1,000-kw. Fraser and Chalmers-General Electric turbo-alternator was installed with the necessary condensing plant, and another Babcock and Wilcox boiler was put down.

It soon became apparent, however, that the plant would be inadequate to meet the demands of the immediate future, which were augmented by the inclusion in the supply area of several outlying villages and districts. Moreover, it was desirable to bring the system into line with other systems with respect to the frequency, so that, in 1923, it was decided to replace the greater part of the existing plant with modern and more efficient machinery, and to alter the supply frequency to 50 cycles. This has now been done, and the new plant was officially opened yesterday by the Mayor of the Borough, Councillor S. Parsonage, J.P.

The present site of the works is unfavourable for further building extensions, and it was therefore necessary to arrange the lay-out so that, when the whole of the installation has been completed, plant of the maximum possible capacity can be housed in the existing buildings. With the arrangement adopted, it will be possible to accommodate three 3,000-kw. sets, two 1,500-kw. sets, and six boilers, each capable of producing 25,000 lb. of steam per hour, but, at present, only the two 1,500-kw. sets and three of the boilers have been installed. The 1,000-kw. Fraser and Chalmers-General Electric set, above referred to, has, however, been re-wound for the new conditions, and will be used mainly as a stand-by, while a Babcock and Wilcox boiler with an evaporative capacity of 16,000 lb. of steam per hour has also been retained. Otherwise the whole of the previously existing plant has been scrapped. The two new turbo-generators, which are illustrated in Fig. 1 on page 482, are of the Brush-Ljungström type and were supplied by the Brush Electrical Engineering Company, Limited, Loughborough, together with the necessary condensing plant. The latter, as shown in Fig. 2, is mounted on the ground level below the turbo-generator in each case. Each set develops its rated output with steam at a pressure of 250 lb. per square inch, and at a temperature of 656 deg. F. at the main turbine stop valve, the vacuum being 28 in. of mercury. The sets run at 3,000 r.p.m., generating three-phase, 50-cycle current at 6,600 volts, and have an overload capacity of 25 per cent. for two hours.

The main bearings, as well as the governor bearings and thrust block, are all lubricated by oil supplied under pressure from a rotary pump of the valveless type, but a separate steam-driven oil pump has been provided in addition, to assist the rotary pump when the set is being started up. Both pumps draw from the main oil tank, and the auxiliary pump is arranged so that it can be started automatically if the oil pressure should fall below a predetermined value. An automatic governor, controlling the movement of the governor valves on the pressure-relay system, is fitted to each turbine and the governor can be adjusted by hand at the set, or by remote control from the switchboard.

The condensers, which are designed to carry the whole weight of the turbo-alternators, are of the Brush two-flow surface type, having 2,500 sq. ft. of cooling surface. They are capable of dealing with 17,000 lb. of exhaust steam per hour, and of maintaining the specified vacuum of 28 in., with the barometer at 30 in., circulating water being supplied at a temperature of 73 deg. F. The air is extracted by Brush-Delas ejector plant, the ejectors being of the two-stage type with the nozzles in series and being capable of extracting 11·85 lb. of dry air per hour. The water is extracted by Pulsometer centrifugal pumps capable of dealing with 30,000 lb. of water per hour and delivering against a total discharge head of 12 ft. They are driven by 2½-h.p. Brush squirrel-cage induction motors running at 1,440 r.p.m. Circulating water is supplied to the condensers by Mather & Platt centrifugal pumps driven by Brush squirrel-cage motors of 27½ h.p. running at 950 r.p.m. The pumps are of the split-casing, low-lift type, capable of delivering 2,100 gallons per minute continuously against a total head of 31·5 ft. when running at the speed mentioned; the circulating-pump motors are controlled by Ellison gear. The air for cooling the alternators is drawn through filters of the oil-film type, the inlets to which can be seen in Fig. 2. They were supplied by the Visco Engineering Company, Limited, and are capable of dealing with 4,500 cubic ft. of air per minute, with an initial resistance of 5-mm. water gauge.

As previously mentioned, one of the old Babcock and Wilcox boilers has been retained, it being intended to use this boiler only at periods of light load during the summer months when the main boilers are shut down for cleaning the flue. The plant will then be operated temporarily at the steam pressure previously employed, viz., 150 lb. per square inch, that being the working pressure of the old boiler, whereas the three new boilers operate at 250 lb. per square inch. These new boilers are of the Clayton-Shuttleworth type, and were constructed by Messrs. Babcock and Wilcox; they were, we believe, the first of the straight-drum design to be erected in this country. As stated above, the normal evaporation of each boiler is 25,000 lb. per hour from and at 212 deg. F., the maximum capacity being 30,000 lb. per hour in each case. Each boiler is fitted with a superheater having 1,120 sq. ft. of heating surface and giving the steam a superheat of about 250 deg. F. An economiser is fitted at the back of each boiler, being carried above the main flue, which is 7 ft. square, and below the boiler-house floor level. The economisers are of Green's tri-tube type, suitable for high pressures, and each has a heating surface of 1,754 sq. ft., giving the feed water a temperature of 140 deg. F. Crosby type

EXTENSIONS AT TUNBRIDGE WELLS POWER STATION.

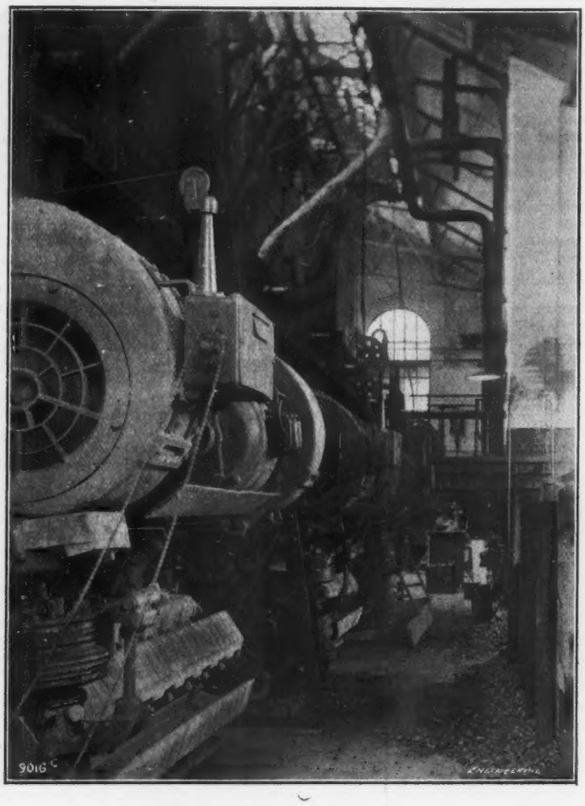


Fig. 3. Underfeed Stokers for Clayton Boiler.

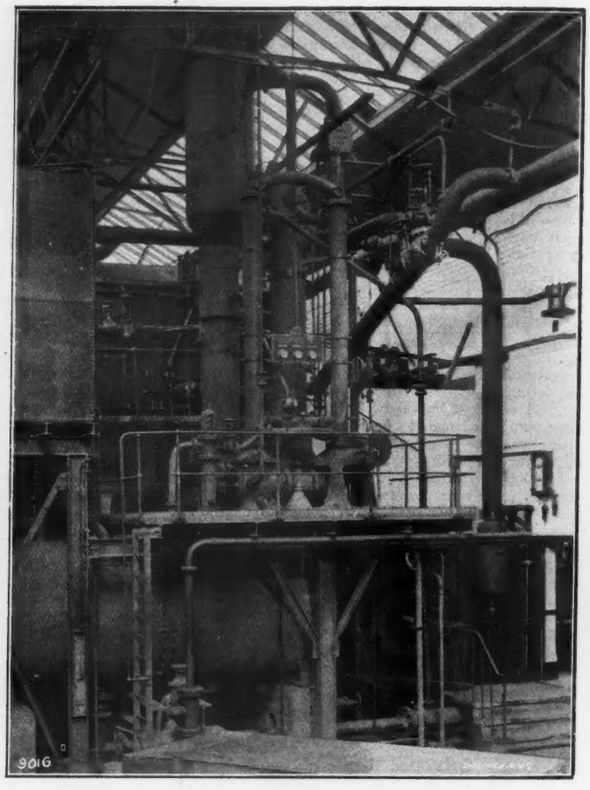


Fig. 4. P. & B. Evaporator for Feed Make-Up.

automatic feed regulators are fitted to the boilers to maintain a constant water level.

The boiler furnaces are fitted with Underfeed stokers, of the self-contained travelling-grate type, the grates measuring 7 ft. 4 in. by 14 ft. 4 in. They are supplied with forced-draught from fans mounted on the front of the stokers, as shown in Fig. 3 above, and driven by the same motors as operate the grates themselves. Coal meters are fitted and the combustion is checked by Duplex Mono recorders, which give continuous records of both carbon dioxide and carbon monoxide, if any of the latter is present in the flue gases. Steam meters of the indicating and integrating types are also provided, as well as temperature recorders, which register the temperature of the flue gases leaving the boiler and entering and leaving the economiser. The temperature of the steam leaving the boiler and that of the water entering the economiser and entering the boiler are also continuously recorded, so that a complete check on the working of the plant can be obtained.

Coal is supplied to the boilers from an external bunker, holding about 160 tons, by an elevator and conveyor which deliver it directly to the stoker hoppers. The ashes fall from the grates into a water-ash conveyor by the Underfeed Stoker Company, the ashes being conveyed in this way along a tunnel below the boilers, out of the boiler house where they are elevated and dumped into a 10-ton ash hopper. From the hopper the ashes can be dumped directly into carts for disposal without the necessity for any man handling. Two sources of feed water supply are available, one from springs and the other from the town mains. Water from the springs is distilled before use in an evaporator plant, supplied by Messrs. P. and B. Evaporators, Limited, and illustrated in Fig. 4. The distilled water produced by this plant passes into a 4,500-gallon reserve tank and thence, through a ball valve, to the make-up tank of the hot well. The town supply is also connected to this tank through a ball valve, which opens automatically so as to maintain the supply in the event of a stoppage of the distilling apparatus. The whole feed system is closed to prevent the water from coming into contact with the air, but to safeguard against the possibility of corrosive water being supplied to the boilers, a Weir corrosion detector has been fitted in the main feed range. The detector comprises a polished steel plate subjected to the full steam temperature on one side, while the feed water passes over the other side. If any corrosive elements are present in the feed, the plate is blackened, this fact indicating the necessity for attention to the feed arrangements. The feed is supplied to the boilers by two rotary pumps—one by the Rees Roturbo Company, and the other by Messrs. G. and J. Weir; the former is electrically driven and the latter is driven by a steam turbine.

To house the switchgear and transformers for the new plant, it was necessary to construct additional buildings, which were erected close to the existing structures with a connection through to the engine room. The old main switchboard, which was, of course, designed for single-phase working, has been altered for use as a high-tension distribution board and now receives two separate single-phase supplies from Scott-connected transformers which convert the three-phase current generated at 6,600 volts and 50 cycles to two-phase current at 2,000 volts at which pressure it is distributed to the various sub-stations in the supply area. The new main switchboard comprises three machine panels, each handling 1,500 kw., at 6,600 volts; three panels for the Scott transformers, two of 1,500 kw., and one of 500 kw. capacity; two works-transformer panels; and one high-tension feeder panel. The panels are composed of concrete cubicles with steel doors, the main 'bus bars being mounted in separate cubicles at the rear. The automatic switches of each panel are designed so as to be capable of breaking safely a short circuit involving the passage of 75,000 kw. This board, we understand, will shortly be extended by the addition of two 3,000 kw. panels, one 1,500 kw. Scott-transformer panel, and four 1,000 kw. feeder panels, which will be required for the further plant extensions above referred to, and for the supply of energy in bulk to neighbouring town of Tonbridge, and to the Weald Electric Supply Company. Opposite the main board, a works-control board has been erected, this board taking three-phase current at 415 volts from the main board, through two 200 kw. transformers, and supplying the various auxiliary motors installed throughout the station. All the new switchgear was constructed by the British Thomson-Houston Company, and the transformers by the British Electric Transformer Company.

It will be readily understood, of course, that the change in the frequency involved considerable alterations throughout the whole area of supply. Many hundreds of motors ranging from ¼ to 75 horse-power are connected on the system and the necessary modifications to these, or to the drives associated with them, had to be carried out at the cost of the supply authority. To facilitate the change, the town was divided into three sections, one of which was changed over at a time, so that two supplies had to be maintained over a period of two months while the work was in progress. Although the preliminary arrangements were carefully organised, it will be obvious that the whole of the motors in any one of the sections, numbering about 150 on an average, required attention almost simultaneously on the day that the actual change was effected. For this reason, the services of practically all the mechanical and electrical engineering firms in the town were requisitioned and with this assistance but little disorganisation of the activities of industrial and other power users resulted. The first section was changed over early in July last, and the change was completed on August 29, when the old single-phase generating plant was finally closed down. The total cost of the change over, we understand, amounted to 2*l.* 16*s.* per horse-power installed—a figure upon which the Borough Electrical Engineer, Mr. R. N. Torpy, must be congratulated.

The Institution of Mining and Metallurgy.—The Gold Medal of the Institution of Mining and Metallurgy has been awarded to Dr. Richard Pearce, M.Inst.M.M., in recognition of the life-long services rendered by him to metallurgical science and industry. Other awards made by the Council of the Institution were as follows:—"The Consolidated Gold Fields of South Africa," Premium of Forty Guineas, to Mr. Thomas Pryor, M.Inst.M.M., for his paper on "The Underground Geology of the Kolar Gold Field"; and the "Arthur C. Claudet" and "William Frecheville" Students' Prizes of ten guineas each, to Mr. F. H. Edwards, B.Sc., and Mr. D. W. Bishopp, A.R.S.M., respectively.

INCREASING THE EFFICIENCY OF THE SCREW PROPELLER.*

By Walter Pollock.

(*Concluded from page* 461.)

In addition to the gain in efficiency as set out in the test results given in Appendix I, there are a number of minor advantages to be obtained by fitting a "Star" contra-propeller—for instance, improved steering is obtained. As rudder "bias" is almost entirely dispensed with, any single-screw vessel fitted with a contra-propeller will steer as easily to port as to starboard and vice-versa. This is a great advantage, especially for cross-Channel steamers, tugs, ferry-boats, and all vessels working in narrow and restricted waters. The results of the trials of the Grotius confirm the advantage of improved steering given by the contra-propeller. This vessel has a length of 420 ft. and required four to five and a half minutes to turn through 180 deg. when steaming at 14½ knots. After fitting the device the time required was only three minutes for the same turn, either to port or starboard. In the case of the ss. Neptun, it is stated that the turning radius was reduced by nearly 40 per cent.

Again, pitching and rolling is reduced when side blades are fitted, with the result that better sea-going qualities in head seas are obtained. In several of the vessels fitted with the device the advantage has been considerable, and in one case it has been stated that the increased speed in a heavy sea was 1½ knots. Vibration also is reduced as the water is less broken (see Figs. 14 and 15). It is unnecessary to emphasise the advantage of this in the reduction of wear and tear and the cost of upkeep and repairs to the main engine and shafting. Another point which is of very great importance in geared-turbine vessels is that the torque variation in the shafting can be reduced by a contra-propeller. A propeller blade, in passing the rudder-post, is subject to a reactionary thrust which momentarily increases the torque in the propeller shaft. With the propeller revolving at a constant speed, there is, therefore, a regular increase and decrease in thrust, and consequently in the torque to which the shaft is subject. Since the reduction gear has a even torque transmitted to it by a very finely balanced turbine rotor, and is working against a regularly varying load in the shafting, stresses are set up which result in wear of the gear and teeth. The greater the number of impulses per revolution, the more even will be the torque on the shaft, since the increase of load due to one impulse is balanced by the decrease of load of the impulse immediately before it. Fig. 16 shows diagrammatically the results of fitting a contra-propeller of type Ib behind a three-bladed main propeller. This figure must not be taken as more than a diagrammatic suggestion of what actually occurs under these circumstances, but it may be of interest to those who have studied the means of measuring the torque in propeller shafts. Further, the blades of the contra-propeller are shaped in such a way as to receive the water without shock. This reduces the intensity of the impulses transmitted to the main propeller, so that the effect of fitting a contra-propeller is not only to reduce the variation in load but also to reduce the maxima of the impulses transmitted due to this effect. Thus, if the proper type of contra-propeller is adopted, the stresses in the gears and the consequent wear can be considerably reduced.

Lastly, several of the types with side blades are a distinct protection to the main propeller against damage by small craft or any floating or partially submerged objects, as the obstruction would be met by the fixed contra-propeller instead of by the main propeller and the ship could still continue her voyage in a satisfactory condition, whereas the consequences of damage to the main propeller are too well known to need elaboration. In this connection may be mentioned the mail steamer Brevik, which has been in continuous service on the south coast of Norway since December, 1921. This vessel is fitted with a contra-propeller, and has rounded lines suitable for ice-breaking, which it is often called upon to do. In this service a piece has been chipped off the main propeller near the tip, but the contra-propeller has not been damaged.

The author acknowledges valuable assistance and contributory information both in the paper and the appendices from Messrs. Alex. Murray, E. W. Harvey, W. Kucharski, Dr. Foerster, and others.

* Paper read before the Institution of Naval Architects, London, on Thursday, April 2, 1925. Abridged.

APPENDIX I.

The figures of Table I will give a good idea of the extent to which the efficiency of several vessels has been increased by fitting a contra-propeller. The Silverpine and Silverlarch, length between perpendiculars 400 ft., breadth moulded 55 ft., depth moulded 38 ft., of 8,500 tons deadweight, each fitted with a marine oil engine of the Neptun B type, having six cylinders 22½ in. diameter by 45 in. stroke and developing 2,250 brake horse-power, were built in 1924.

The Silverpine ran her trials without the "Star," and the Silverlarch ran trials with the "Star," in order that the comparison might be made. In this case the contra-propeller was of type Ia (see Fig. 4) and the trials were the usual light-draught trials carried out by the builders on completion. The results of voyages on actual service are expected to show a still greater improvement. From the figures given in Table I it will be seen that an increase of 6·66 per cent. in speed was obtained for practically the same brake horse-power. The decrease of 4·6 per cent. in the slip is typical of the increased propulsive efficiency of a well-designed contra-propeller, and as the trials were run over the same measured mile under similar weather conditions, they may be taken as giving a very fair comparison of results with and without a "Star."

Table I.—*Trials of Silverpine and Silverlarch.*

	Silverpine. (without c.p.).	Silverlarch. (with c.p.).
Propeller—		
Diameter	14 ft.	13 ft. 10½ in.
Pitch	11 ft. 9⅛ in.	11 ft. 9 in.
Number of blades	4	4
Material	Cast iron.	Cast iron.
Draught—		
Forward	9 ft. 6 in.	9 ft. 2½ in.
Aft	16 ft. 2 in.	16 ft. 3½ in.
Mean	12 ft. 10 in.	12 ft. 8½ in.
Displacement	5,576 tons.	5,526 tons.
Displacement coefficient	0·696	0·695
Midship area	684 sq. ft.	671 sq. ft.
Midship area coefficient	0·97	0·97
Propeller tips immersed	13¾ in.	15½ in.
Speed, knots	11·11	11·85
Slip, per cent.	9·4	4·8
Revolutions per minute	105·4	107·25
Brake horse-power	2,070	2,085

The Thuringia and Westfalia are sister ships of 11,600 tons gross and 5,000 i.h.p., each fitted with a single screw. Several voyages with and without the "Star" contra-propeller were made to and from Hamburg and New York, particulars being given in Table II. Type Ia was fitted in each case.

	Old Propeller.	New Main Propeller.	New Main Propeller and "Star" c.p.
Either at 800 I.H.P. :—			
Speed, knots	11·1	11·3	11·65
Increase in knots over old propeller	—	0·2	0·55
Percentage increase in knots over old propeller ..	—	1·8	4·95
Or at 11·6 knots :—			
I.H.P.	1,000	900	775
Decrease in I.H.P. over old propeller	—	100	230
Percentage decrease in I.H.P. over old propeller ..	—	10	23

In the case of the Thuringia, bilge-keels were fitted at the same time as the contra-propeller, whereas the Westfalia had bilge-keels fitted during the whole nine voyages.

The ss. Neptun, with dimensions, length between perpendiculars 218 ft. 10 in.; breadth, moulded, 29 ft. 7½ in.; depth, moulded, 15 ft. 4½ in.; fitted with triple-expansion surface-condensing engines having cylinders 22½ in., 36½ in., 57½ in. by 35½ in. stroke; and two boilers, each with three furnaces—gave the results shown in the diagram, Fig. 17. Trials were run in 1922. First trial with original propeller, 1,265 tons displacement; second trial, with new main propeller, 1,240 tons displacement; and third trial, with new main propeller and "Star" contra-propeller, 1,205 tons displacement—all run on measured distance of 6·806 miles, at the same speeds under moderate weather conditions. The second trial showed a saving in I.H.P. over the first trial

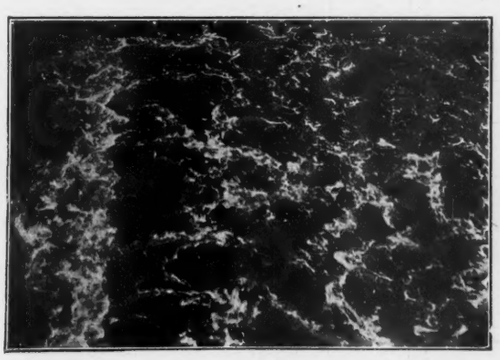
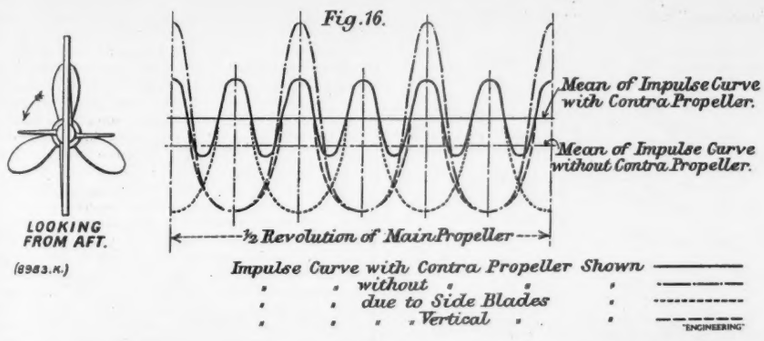


Fig. 14. Ship's Wake with Star Contra-Propeller.

Fig. 15. Ship's Wake without Star Contra-Propeller.



THE EFFICIENCY OF THE SCREW PROPELLER.

Fig. 17. S.S. "NEPTUN."

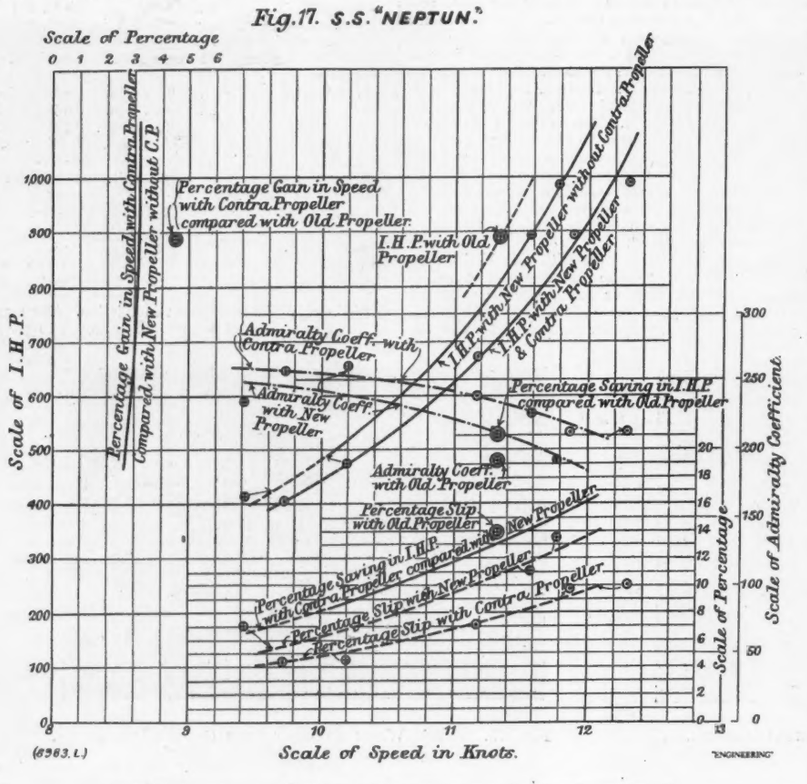

Scale of Percentage
0 1 2 3 4 5 6
Percentage Gain in Speed with Contra Propeller compared with New Propeller without C.P.
Percentage Gain in Speed with Contra Propeller compared with Old Propeller.
I.H.P. with Old Propeller
I.H.P. with New Propeller without Contra Propeller
I.H.P. with New Propeller & Contra Propeller
Admiralty Coeff. with Contra Propeller
Admiralty Coeff. with New Propeller.
Admiralty Coeff. with Old Propeller.
Percentage Saving in I.H.P. compared with Old Propeller
Percentage Slip with Old Propeller
Percentage Saving in I.H.P. with Contra Propeller compared with New Propeller
Percentage Slip with New Propeller
Percentage Slip with Contra Propeller
Scale of I.H.P.
Scale of Percentage
Scale of Admiralty Coefficient.
Scale of Speed in Knots.
(6363. L.)
"ENGINEERING"

TABLE II.—DATA OF VOYAGES OF SS. "THURINGIA" AND "WESTFALIA."

Voyage.	Mean Draught.	Speed, Knots.	Slip.	Revolutions per Minute.	I.H.P.	Remarks.
		S.S. "Thuringia."				
	ft. in.		Per cent.			
1st to 9th round voyage	24 1	12·75	4·8	80·5	5,190	Without "Star" contra-propeller
10th to 12th round voyage	25 3	13·03	0·0	78·5	5,180	With "Star" contra-propeller.
		S.S. "Westfalia."				
1st to 5th round voyage	24 0	12·7	6·6	81·7	5,150	Without "Star" contra-propeller.
6th to 9th round voyage	25 8	13·3	4·25	82·7	5,190	With "Star" contra-propeller.

	"Thuringia."	"Westfalia."
Required I.H.P. without "Star" contra-propeller reduced to the speed and draught of the voyage with "Star"	5,790	6,220
Actual I.H.P. on voyage with "Star"	5,190	5,150
Saving effected by "Star"	600	1,070
Percentage saving	10·4	17·2

conditions of 5 per cent., and the third trial a saving of 17 to 21 per cent. It will be noted from the diagram that the new main propeller was an improvement on the original, but with the "Star" the saving was of such magnitude that it made a striking example, as set out on the previous page.

For towing and manœuvring the "Star" shows equal results with those obtained from deep-sea ships. The first practical experiments with the "Star" were, in fact, carried out on tugs, and the increased efficiency was clearly demonstrated in that, with the same speed and the horse-power, the weight of the vessels towed could be greatly increased. The increased efficiency due to the fitting of a "Star," rising as it does in some cases to 20 per cent., is arrived at after the loss due to the resistance offered by the "Star" has been allowed for.

RESEARCH IN ORE DRESSING.

THE necessity of a study of the problems encountered in the dressing of ores and of minerals having been urged upon the United States Bureau of Mines by the Milling Committee of the American Institute of Mining and Metallurgy, the Bureau inaugurated a survey of the conditions of research in the reduction and concentration of ores and minerals. The survey was carried out in 1923 under the supervision of Mr. D. A. Lyon, director of the Bureau, with co-operation of the Institute mentioned, of Professor E. A. Hersam of the University of California, and of the Massachusetts Institute of Technology. The preliminary report, drawn up by Professor Hersam, was published last month under the title "The Status of Research on Ore Dressing" (Investigation Reports, Serial No. 2669). A considerable amount of experimental work, we learn, is being carried on at great cost, but the research is poorly co-ordinated. The expense falls mainly upon mining companies and firms; other industries profit, and there are fundamental problems which cannot be solved by individual research. The influences of hardness and cleavage of rock and of coarseness of grain on crushing and grinding machinery and their power consumption are imperfectly understood. "The facts underlying ore flotation are partly known by few, and entirely by none," the report states; magnetic and electrostatic ore separation require much further study. A great variety of devices and processes, also concerning coal and clay, are briefly reviewed in the report; the objects of the experiments in progress are pointed out, and if the descriptions of the machines, mills and tables, &c., are short, the names of the mines and firms are given, so that further inquiries can be made. Canadian practice is also noticed.

As regards crushing and grinding, the report points out that no set of machinery could be standardised for all ores and conditions, and that the first aim should be to work out a method for determining the efficiency of crushing machinery. The efficiency depends upon the hardness and toughness, plasticity and elasticity of the material and other factors, and these features, with the moisture and grain size desired, are not given due consideration in selecting the type of machinery. Rolls, frequently used in stages, were found to compare favourably with other crushing machinery in their simplicity and capacity for dealing with intermediate sizes; but they were subject to much wear and reduction of efficiency with hard angular rock. Little had been gained by multiplying the number of rolls and by reducing their sizes for fine crushing and for higher speeds. In the Lake (copper) district, rolls were worked in conjunction with steam stamps. In beaters, impact pulverisers and cyclone mills the effect was not merely due to the high velocity of the impact. A selective action was intended to allow certain material to escape, but the theoretical advantage of the impact principle remained to be proved. The principle had never yet been applied in any machine that could be made practicable for long general use. The rod mill had been found to be more efficient and less liable to wear than the ball mill, especially for delivering thick, fine pulp; in El Paso a mill was operated with 40,000 lb. of 3-in. by 12-ft. rods to crush several thousand tons of ore of 1 in. size down to 10 mesh per day. Long tube mills had proved less efficient than short mills, and the free discharge of material from tubes left something to be desired; the heaviest materials, including sulphides, were apt to be seriously slimed. In the Fairchild ball mill provision was made for feeding the material midway between the trunnion ends; the mill had for this purpose to be divided into two compartments by a partition which enclosed two spiral elevating channels leading from peripheral intakes to central feed openings. Ball-mill linings were being made of steel rails, sawed to 4-in. lengths, and cement, or of rubber sheeting, $\frac{7}{8}$ in. thick, and pure rubber. As regards bearings for ball mills, nickel seemed to stand best; the replacement of Babbitt metal by brass did not appear to be quite justified. Promising results had been obtained with steel slugs, cylinders 1 in. high and 2 in. long, and also with concave balls, having polar concavities or flat portions, or rough balls of ores, and also with rough linings of tube mills. E. Koepel, it is interesting to mention, is investigating the hardness of the interior of worn-down steel balls.

The classification used in connection with closed-circuit grinders should not be merely by size. The prevention of the return to the mill of the sulphides together with the coarse sand was important. Another source of trouble to which attention is drawn is the segregation of crushed materials subsequently in handling and in feeding devices. As regards separation and grading, the grizzly, trommel, shaking screens and vibratory screens are used in that order to obtain finer material. Rapid vibratory screens are in favour for the dry screening of coal. By superposing $3\frac{1}{2}$ mesh screens on the finer 10 mesh in Colorado impact screens, the life of the latter has been prolonged from 32 to 96 hours. The report speaks well of the Dorr bowl classifier; automatic classifiers are being studied by A. W. Fahrenwald. For pneumatic concentration the material should be absolutely dry; it is, moreover, sometimes overlooked that the separation of two materials like pyrite, density 5, and gangue, density 2·5, is more effective in water, where the density ratio is $(5-1):(2{\cdot}5-1)=2{\cdot}66$, than in air, where the ratio is $5:2{\cdot}5=2$. Concentration by flotation, the report makes clear, must not be regarded as so simple and universal as is sometimes asserted, though it is certainly gaining ground. In spite of the use of chemicals comprising sodium sulphide and disodium hydrogenphosphate, the separation is not always successful, and lead and silver can sometimes only be separated by the sacrifice of all the zinc present. Practice favours shallow flotation cells. In any case classification should precede flotation; the old tables, slime tables, and other gravity concentration methods quite hold their own, while the simple vanners (rubber-belt concentrators) seem to be replaced by impact and accelerated-motion machinery, sometimes undeservedly, according to the report. In view of the uncertainty of the action of flotation agents, oils, acids and alkalis, the report suggests a study of the action of these agents on impact tables and of their possible interference with concentration subsequent to flotation.

STANDARD SPECIFICATIONS FOR BOLTS AND NUTS.—The British Engineering Standards Association, of 28, Victoria-street, Westminster, London, S.W.1, has just published specifications No. 190–1924, entitled "Dimensions for British Standard Whitworth (B.S.W.) Bright Hexagon Bolts, Set-Screws and Nuts, Split-Pins, Washers and Studs," and No. 191–1924, headed "Dimensions for British Standard Fine (B.S.F.) Bright Hexagon Bolts Set Screws and Nuts, Split Pins, Washers and Studs." The first of these publications supersedes Table 1 of leaflet No. 28–1908, "Nuts, Bolt Heads and Spanners," and also those sections of the latter dealing with castle nuts, while the second specification replaces publication No. 54–1911, "Threads, Nuts and Bolt Heads for use in Automobile Construction." The material contained in these latest specifications has been issued in the form of varnished charts for use in the drawing office, and the workshop. These specifications and charts may be obtained from the Publications Department of the Association at a price of 1*s.* 2*d.* and 1*s.* 3*d.* respectively per copy post free.

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.

Fig. 1.

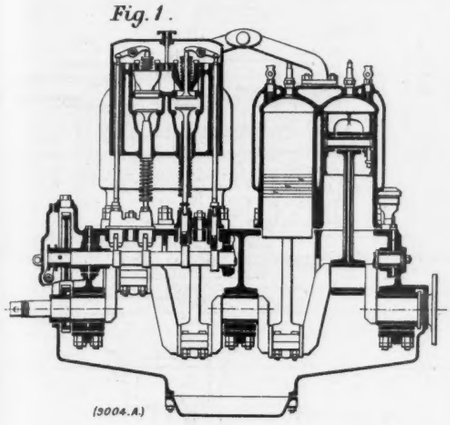
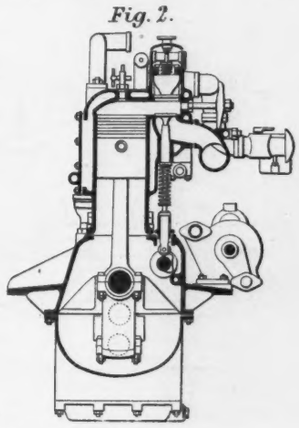


Fig. 2.



FIGS. 1 AND 2. SCHNEIDER 4-CYLINDER MOTOR, 60–80 H.P.

Fig. 3.

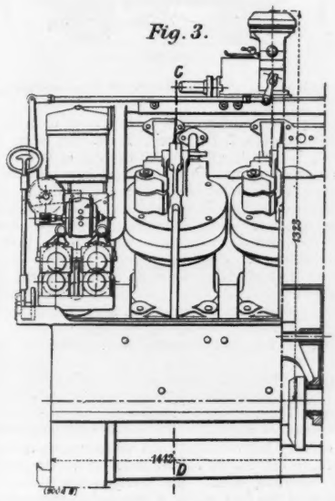
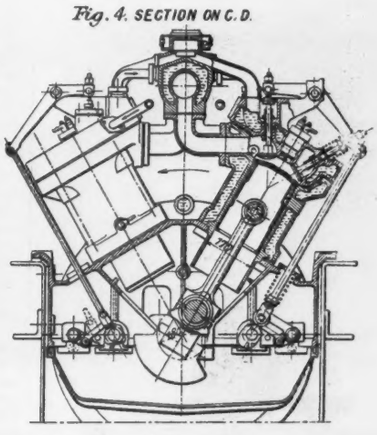


Fig. 4. SECTION ON C.D.



FIGS. 3 AND 4. DEUTZ 6-CYLINDER MOTOR.

Fig. 5.

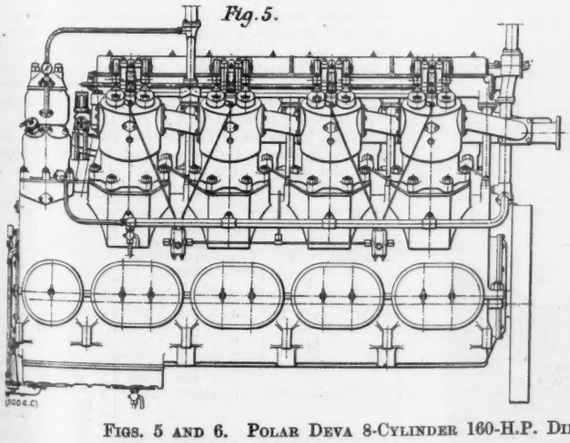
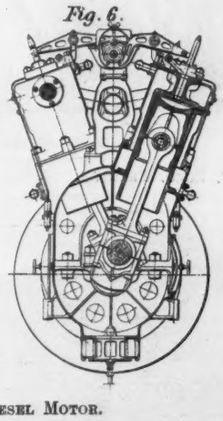


Fig. 6.



FIGS. 5 AND 6. POLAR DEVA 8-CYLINDER 160-H.P. DIESEL MOTOR.

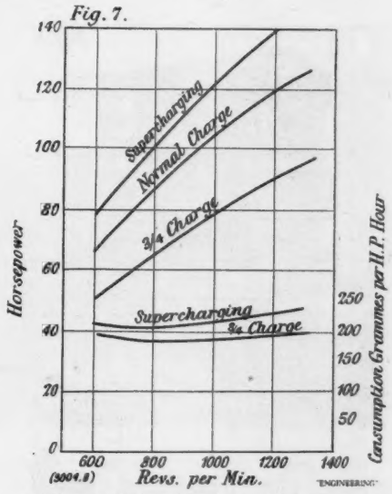
TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.*

By M. EUGENE BRILLIÉ.

By the term "internal-combustion engines," two classes of engine are covered. In the one, the combustion, or rather explosion, takes place at constant volume; in the other class, that of combustion motors properly so-called, the combustion takes place at constant pressure. The explosion motor which revolutionised transport on road and made mechanical flight possible, has also found its application to traction on rails. Numerous examples of this kind show the varied services which the automobile type of engine can render for work requiring only small power. On the other hand, the internal-combustion engine of the Diesel or other type, the use of which is spreading for propulsion of ships, particularly outside France, has proved itself undoubtedly to be the motive power of the future. The heavy oil engine has also the necessary qualities for ensuring traction on rails at low cost, and in time will compete with steam.

* Paper read before the British Section of the Société des Ingénieurs Civils de France on April 1, 1925. Abridged.

Fig. 7.



The range over which these two types of motors can be applied extends from the small light rail locomotive weighing from 1 to 2 tons, up to a heavy locomotive of 100 tons and upwards. At the exhibition of railway rolling stock held in Berlin and Seddin in October, 1924, many interesting examples of these new methods of traction were to be seen which showed the progress which is now being made in Germany. At Seddin there were a number of shunting locomotives, six of which were fitted with Diesel motors of 150 to 400 h.p., and seven or eight rail automotor vehicles, several of which were fitted with two engines.

The advantages of the internal-combustion engine over the steam engine as a method of propulsion may be summed up as follows: Ability to start work at once (saving the time required for steam-raising); possibility of being driven by a single employee; great length of journey without taking in supplies, rendered possible by the small weight of supplies consumed, particularly of water; ability to run continuously day after day (saving the time lost in filling with water and fuel, cleaning fires and sweeping tubes); and suppression of smoke and of fire-throwing. Some other advantages, such as the absence of glare, of smoke, and of need for water-cranes, are of peculiar value from the military point of view, and enabled the services rendered by this class of traction on rails at the front during the war to be appreciated.

The above advantages include those of a commercial nature relating to the saving effected, and it should be added that the greater calorific efficiency of the internal-combustion engine over the steam engine enabled considerable saving to be made in the cost of fuel, particularly in engines working with heavy oil. This efficiency, put in terms of consumption, can be compared as follows: In the steam engine, the efficiency is generally taken as varying from 6 to 9 per cent. according to the type of locomotive; it would attain 15 to 18 per cent. on the turbine condensing locomotive. In the case of the internal-combustion engine, the efficiency reaches 32 and even 35 per cent. at the engine shaft. If the efficiency of the transmission is taken at 70 per cent., the overall efficiency of the fuel will amount to 22 to 25 per cent. at the periphery of the driving wheels.

The use of the internal-combustion engine for traction, however, raises a number of problems that are non-existent in the case of the steam engine. The steam engine with its direct drive to the wheels, has a flexibility that enables it to adapt itself to all the conditions of running from starting up to the highest speeds. The internal-combustion engine, on the other hand, requires auxiliary arrangements to enable it to transmit its power to the wheels, and to adapt itself to the various running speeds.

Explosion Engines.—All varieties of motors of the automobile type can be, and have been, adapted in many cases for powers up to 80 h.p. The conditions on railways are not such as to require the lightness which is necessary for traction on roads, hence these motors are often worked at lower speeds with a view to obtaining a longer life. The fuels used in these engines comprise the volatile hydrocarbons, petrol, benzol, carburated alcohol, &c. Trials have been made with heavier hydrocarbons, such as paraffin oil or gas-oil,

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.

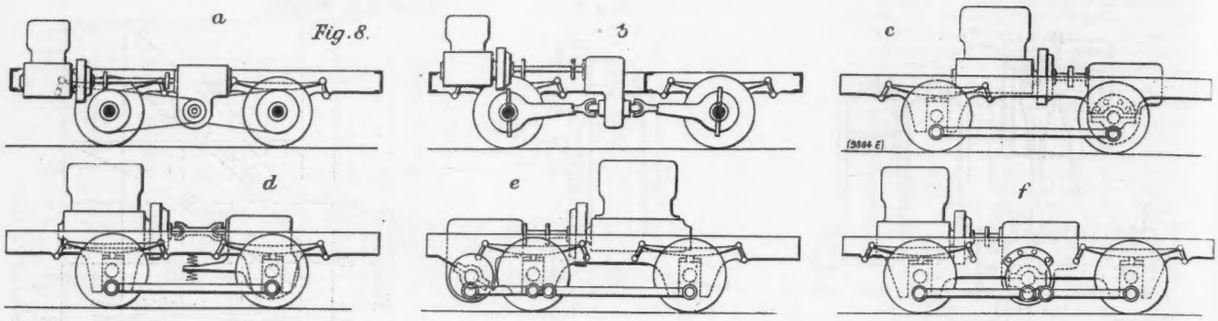


Fig. 8.

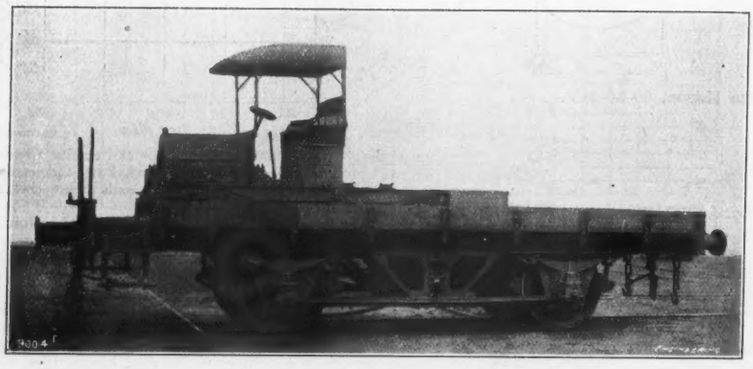


FIG. 9. PLATFORM LORRY MODIFIED FOR RAIL TRACTION.

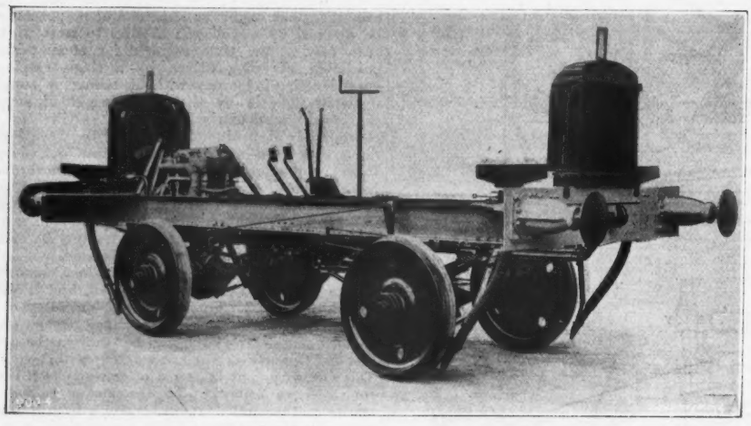


FIG. 10. F.W.D. 40-H.P. LOCO. TRACTOR.

FIG. 12. 100-H.P. BAUDET-DAUNON LOCOMOTIVE.

Fig. 11.

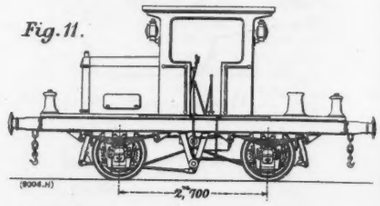


FIG. 11. 15-TON BERLIET LOCOMOTIVE.

either by means of special carburettors or by motors specially designed for these fuels. In such cases, starting is usually effected by the aid of petrol. The use of producer gas or suction gas has been adapted to some rail locomotives and motor vehicles; it will become of considerable interest when the space occupied by the generator and accessories ceases to be unreasonable. Compressed town gas has also been used in some instances. Finally, we may mention that the large central electric stations are making the use of hydrogen possible, as the gas can be produced at low cost by electrolysis, a method which is being developed in Germany.

Figs. 1 to 6 show examples of internal-combustion engines in use for rail vehicles; they include the ordinary automobile engine of the usual types; vertical or V-engine, T, side-by-side and overhead valve arrangements; sleeve valve engines are also in use.

Combustion Engines.—The Diesel-cycle engine makes use of very high compression pressures, ranging from 450 lb. to 500 lb. per square inch. The high temperature resulting from this compression ensures the ignition of the fuel, which is injected as spray at about the top dead centre of the piston. The spraying or atomisation may be effected either by an air blast at high pressure, about 900 lb. per square inch, or it may be sprayed mechanically through very small holes at a very high pressure ranging from 3,000 to 6,000 lb. per square inch; this is the method known as solid injection. The motors used are either two or four cycle; they work with heavy oil (gas-oil) or with vegetable oil, the latter being a fuel of particular importance for Colonial work.

Manufacturers have constructed motors that are specially applicable for purposes of traction of high-speed and light weight, particulars of some of which are shown in the following table:—

Manufacturer.	Cycle.	No. of Cylinders.	Revolutions per Minute.	Horse-Power.	Remarks.
Sulzer ..	2	6	440	200	Compressed air spraying.
Polar	4	6	550	75	Compressed air spraying.
Deva	4	6	550	120	Compressed air spraying.
Deva	4	8	550	150	Weight about 90 lb. per horse-power
Deva	4	12	550	250	Weight about 90 lb. per horse-power
Maybach ..	4	6	1,300	120–150	Compressed air spraying. Weight about 18 lb. per horse-power.
Winterthur*	4	3	550	100	Solid injection

* See ENGINEERING, December, 1924.

The characteristic curves of the Maybach engine are shown in Fig. 7.

The Baden engine, constructed by Benz, is also a four-cycle engine using solid injection.

For higher powers, ranging from 400 h.p. to 1,200 h.p. for example, the submarine type of engine can be brought into use. Experiments and examples of construction of this character have been made by the

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.

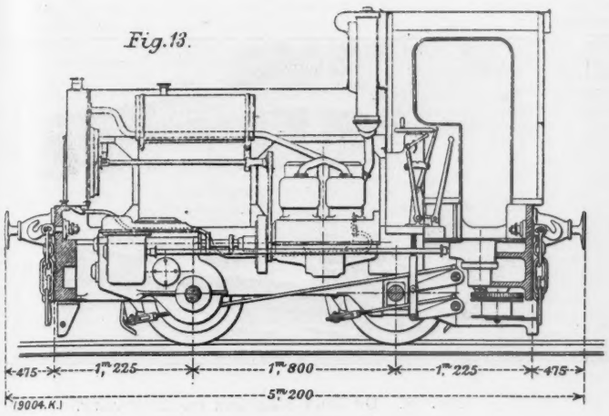


FIG. 13. SCHNEIDER LOCOMOTIVE; SECTION.

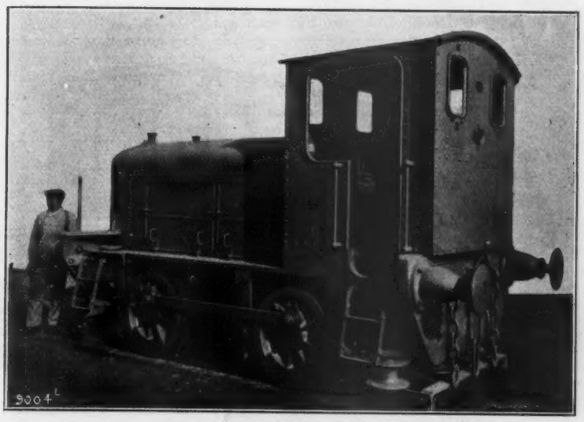


FIG. 14. SCHNEIDER LOCOMOTIVE; GENERAL VIEW.

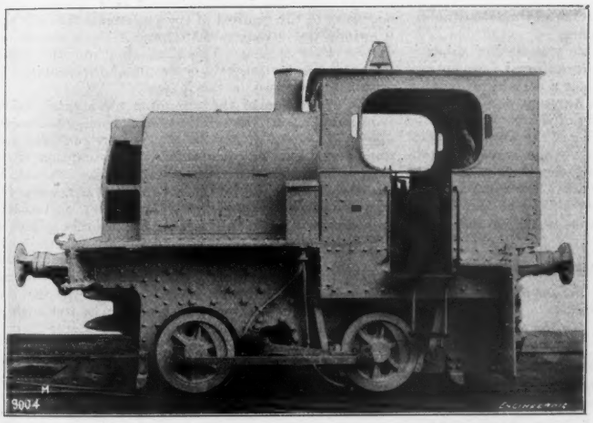
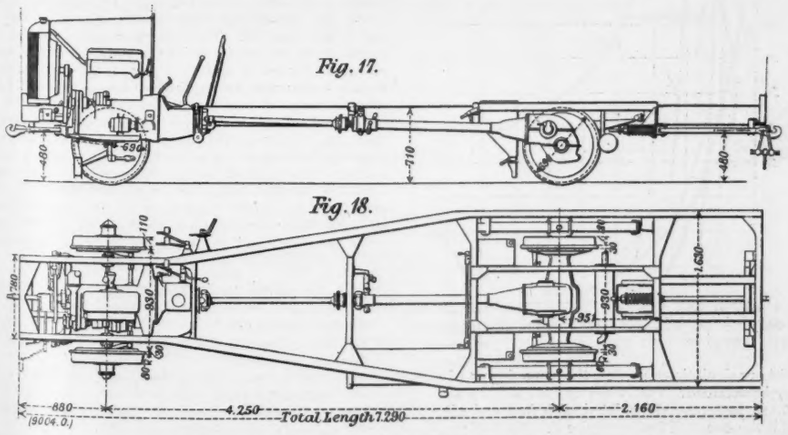


FIG. 15. 55-H.P. LEROUX LOCOMOTIVE.

FIG. 16. 60-H.P. RENAULT LOCOMOTIVE.



FIGS. 17 AND 18. DE DION RAIL CAR CHASSIS.

use of M.A.N. engines in Germany, and engines of the Fiat, Beardmore and Schneider types in Italy, England and France.

The class of internal-combustion engines includes those often called semi-Diesel, with hot compression chamber and of the two-cycle type. This class of motor can be of rougher construction than the Diesel engine, but it is somewhat less economical, and has the disadvantage of requiring the heating of the chamber before it can be started. It has nevertheless been used in several instances for traction.

Mechanical Methods of Transmission.—Many of the transmission gears are direct derivatives of those of the automobile. They are identical with the latter in the case of some vehicles that are only required to run in one direction, and can, therefore, be fitted with a single reverse speed. In most cases, however, the locomotive should be fully reversible, and, consequently, have the same range of speeds forwards and backwards. Reversing may either be effected in the bevel drive or by a train of spur gears.

Various methods of driving the wheels are shown diagrammatically in Fig. 8. The several sketches show: (*a*) Chains driving through an intermediate pinion. In a variant of this, one of the axles is driven by a chain, and the other axle connected to the first either by a chain drive or the ordinary arrangement of coupling rods; (*b*) Driving through cardan joints; (*c*) Direct drive from a pinion on the driving shaft gearing with a toothed wheel on the driving axle; the latter is not spring-suspended and runs in journals that are fixed to the gearbox casing. The other axle, fitted with springs, is connected by coupling rods or by a chain drive to the driving axle. This somewhat rudimentary arrangement is well suited to locomotives running at very low speeds; (*d*) Both axles are carried on springs; one of them carries the gearbox in which it revolves; the box is attached at the other end to a support carried on the frame, either fitted with spring checks or without; owing to its change of inclination, the gear is driven from the engine by means of a cardan shaft. (*e*) and (*f*) Transmission by dummy axles and coupling rods. The dummy axle runs through the gearbox in which it is driven by gearing.

In these various examples, a clutch, carried on the flywheel of the engine and a gear-changing arrangement are shown; the gears may be of the sliding type usual in automobiles, or they may be permanently engaged and the clutching for different speeds effected by dog clutches. Some locomotives have two speeds and two clutches controlled by a single lever; in other locomotives the two clutches control respectively forward and reverse running. There are other methods in use which will be examined below.

The arrangements just mentioned are shown in the examples illustrated in Figs. 12 to 20, which show locomotives for normal gauge lines. It will be noted that some of them are variants of the ordinary four-wheeled road vehicle adapted to rails (Figs. 19 and 20), and others are of the flat-topped lorry type converted into rail motor cars (Figs. 9 to 11), while others more closely resemble the recognised form of the locomotive.

(*To be continued.*)

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.

(*For Description, see Page* 493.)

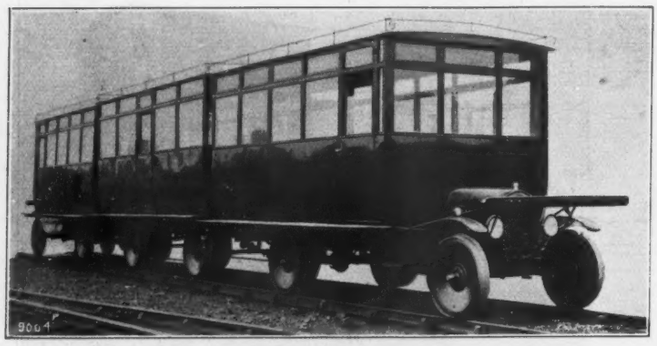


FIG. 19. FORD RAIL CARS WITH INTERMEDIATE TRAILER.

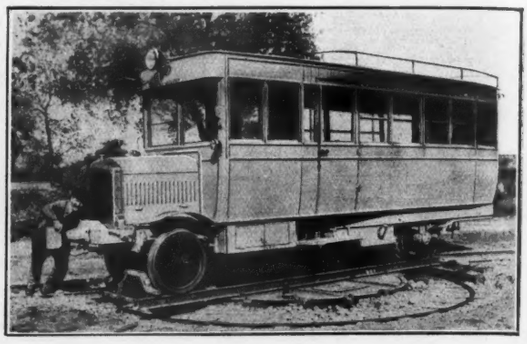


FIG. 20. DE DION RAIL CAR ON TURNTABLE.

STABILITY AND SEAWORTHINESS.*

By C. FRODSHAM HOLT, M.Eng.

WHEN a ship proceeds to sea upon any given voyage it is very rarely that the metacentric height is known with any degree of accuracy. Even if the actual metacentric height is known, it cannot be said from inspection whether the stability is and will remain satisfactory during the voyage. Before attempting to discuss how best to give information to the shipmaster regarding the safety of his ship, it is necessary to decide what constitutes safe stability. Individuals have expressed opinions as to the safe metacentric height for a given ship or type of ships; little attempt seems to have been made to justify these opinions by testing them against the physical facts which the problem affords. The investigations of Lloyd's Committee on Masting are an outstanding exception to this generalisation; but their findings were of a special nature, the direct utility of which has passed away with the sailing ship. We will first consider what seaworthiness consists in, and then show how it is obtained. It must be noticed that what follows applies to any ship in seagoing trim, and does not deal with intermediate conditions which may arise in port; it does not concern the design of ships, but applies directly to every ship, as built, no matter how badly designed or difficult to operate.

The first condition essential to seaworthiness is that the ship shall never be unstable when upright, at the beginning or the end of any given voyage, or while at sea. The second condition of seaworthiness is that the worst conjunction of wind and waves that can possibly be encouraged during the given voyage shall not cause the ship to roll beyond the safe effective range of heel. The lower limit of safety in service is reached when the ship becomes unstable in the upright position.

Initial instability at sea is dangerous for two reasons: the ship is very easily inclined by wind pressure, and if one course is held for a long time there is a great tendency for cargo or coal to shift, so that an angle of heel is accumulated which continually tends to become greater. The dangers of a heavy list at sea are obvious; it also introduces errors in the magnetic compass and causes a considerable increase in draught. In passenger ships initial instability has the further objection of rendering it difficult or impossible to launch the life-boats on one side, if the ship has to be abandoned. In order to maintain this limiting degree of safety under actual service conditions, the vessel must sail with a sufficient margin of metacentric height to cover any losses of stability which may occur during the voyage from the following causes:—

1. It is necessary to commence any given voyage with such a metacentric height that the consumption of fuel, fresh water, and stores will not reduce that height to zero at any time during the voyage, after due allowance is made for the possibility of using additional water ballast during the voyage to compensate for this loss.

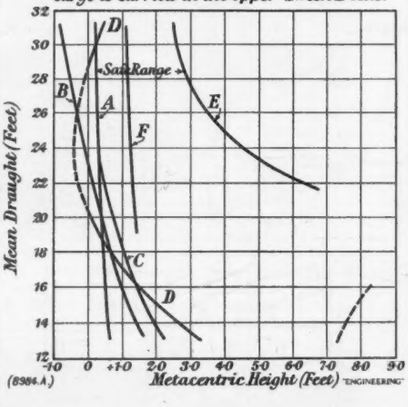
2. The margin of metacentric height at the time of sailing should further cover for the loss of initial stability caused by the free surfaces in fresh-water and oil-fuel tanks and bunkers which is inevitable while they are in use. Also when water ballast must be added at sea, it should be done while there is sufficient metacentric height to cover any temporary loss while the filling operation is in progress. The allowance for oil bunkers and freshwater tanks should be based on the free surfaces of all the tanks which may be in use at any one time.

3. A further margin is required at all times to counteract the heeling action of the helm.

4. In passenger ships a certain standard of subdivision is enforced under the International Convention. The ship is designed to float after a certain proportion of her buoyancy has been lost through damage. The initial stability at the beginning of the voyage must be sufficient to allow for the flooding of the worst compartment at any time during the voyage and yet retain initial stability. In calculating the margin of safety necessary to cover this requirement, the same assumptions with regard to the permeability of the flooded compartments should be made as in the standard subdivision calculations, so that the same degree of safety may be attained.

Fig. 1. SAFE RANGE OF METACENTRIC HEIGHT.

A Minimum Metacentric Height to cover for Free Surfaces in Tanks.
B Minimum Metacentric Height to cover for Flooding by Damage.
D&E Minimum and Maximum Metacentric Heights for Safe Rolling at Sea.
F Maximum Safe Metacentric Height when Bulk Cargo is carried in the Upper Tween Decks.



5. In passenger ships fitted with fore and aft bulkheads the Board of Trade require that the heel produced when the wings are flooded for a distance equal to the "permissible length" of compartment, shall not exceed about 7 deg., in order that the life-boats may be worked safely. This requirement is not part of the printed regulations, but is nevertheless their practice. If these bulkheads are actually fitted, it becomes necessary always to maintain such a reserve of initial stability as to limit the heel produced by flooding to 7 deg.

6. A similar reserve is necessary in excursion steamers and ferry-boats, where the weight of passengers is large. It is usual to assume that all the passengers may crowd to one side of the ship, their centre of gravity being at one-quarter of the beam from the centre line. To prevent excessive heel under such circumstances the initial stability while in service must have a certain minimum value, which varies with the draught.

7. In first-class passenger ships it is often thought necessary to the comfort of the passengers that the heel to winds not stronger than force 4 or 5 should not exceed 1 or 2 deg. This limitation on the initial stability does not strictly come under the definition of seaworthiness used in this paper.

The evaluation of the minimum metacentric height required to ensure that all the contingencies enumerated above are covered, can be effected by ordinary well-known methods of calculation. The condition of the ship throughout the projected voyage should be examined; it may often happen that it is necessary to commence the voyage with a greater metacentric height than is immediately called for, in order to provide against conditions arising at later stages.

In Fig. 1 the minimum metacentric height required to satisfy the condition that the initial stability will not become eliminated during the voyage by the consumption of fuel, water, and stores, or by free surfaces in the tanks and bunkers is given by Curve A on a base of draught at the beginning of the voyage. Curve B shows the minimum metacentric height for flooding a distance equal to the "permissible length"; it will be noticed that at deeper draughts a gain in initial stability results from flooding; at lighter draughts, a loss. Below the point where Curve B crosses the vertical axis, it is necessary to add the ordinates of Curves A and B in order to obtain the minimum metacentric height, and Curve C is obtained. In cargo ships, to which the subdivision rules do not apply, Curves B and C are omitted. The minimum safe metacentric height based on considerations of initial stability, and shown in Curves A and C of Fig. 1, is not absolute. Higher values may be required to ensure that the safe effective range of heel is not exceeded.

The safe effective range of stability depends partly upon the nature of the cargo carried. In passenger ships and in cargo ships carrying bale cargoes it is limited by the angle of heel at which any of the following openings in the decks or erections, whose closing appliances are either temporary or not equivalent in strength and watertightness to the hull of the ship, enter the water and become liable to broaching under the direct blows of storm waves:—

Cargo or bunker hatches not fitted with watertight covers;
Fiddley gratings;
Wooden skylight and companions;
Tonnage openings;
Openings in the ends of erections not fitted with watertight doors;
Ordinary weather doors in deck-houses covering access to the main interior of the ship.

The importance of the security of openings in erections has been recognised by the Load Line Report of 1916, in which the freeboard assigned is made to depend on the type of closing appliances fitted. In ships carrying cargoes in bulk, the safe range of heel is alternatively limited to the virtual angle of repose of the cargo; the statical angle of repose is altered by the forces arising from the rolling of the ship.

The ship at sea is acted upon by two systems of forces which cause her to incline from the upright—those due to the wind and the waves. There are methods of estimating the angle of heel rolled to by the ship; but there is no standard method of calculation such as is used in making statical stability calculations,

* Paper read before the Institution of Naval Architects, London, on Friday, April 3, 1925. Abridged.

nor is there any recognised basis for assessing the worst weather conditions encountered by the ship.

In view of the investigations of the late Dr. R. E. Froude,* and of the fact that all ships, except those of very long periods, are liable to find waves with which synchronism can take place, it may be taken as true that if the safe effective range of heel is not exceeded under conditions of synchronism with the waves, it will not be so under any other condition. Thus the standard condition for rolling among waves to be considered in discussing the seaworthiness of the ship can be taken as that arising from synchronism of the ship's period with that of waves having the maximum wave-slope. In order to determine the maximum angle θ is measured in degrees. a is a constant, independent of absolute size, which can be shown to account for the surface disturbance caused by the rolling, and the virtual increase in the mass. b is a constant, independent of absolute size, which accounts for frictional resistance, eddy making, and bilge keel resistance. a is larger than b, and is the more important at small and moderate angles of heel; at large angles such as those occurring during synchronous rolling, the first term is almost negligible in magnitude. If the deck edge becomes immersed, both constants will probably become greater.

From the work of Dr. Froude on rolling, it can be said that the increase in the angle of heel with each

Fig. 2. MAXIMUM SURFACE SLOPE & EFFECTIVE SLOPE OF STORM WAVES, UNDER THE WORST WEATHER CONDITIONS

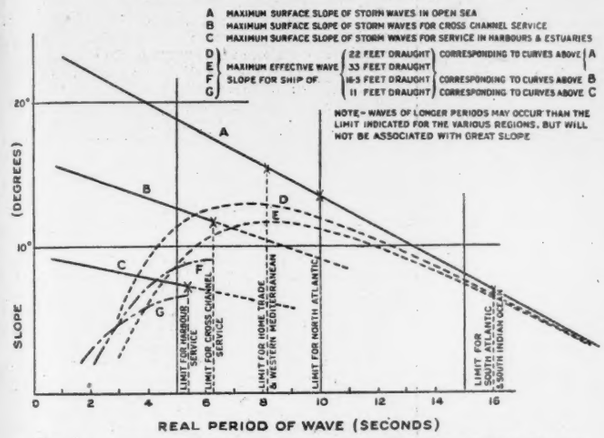
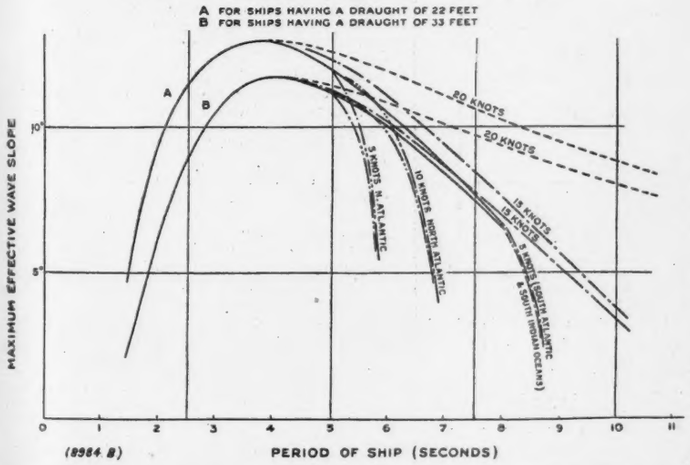

A MAXIMUM SURFACE SLOPE OF STORM WAVES IN OPEN SEA
B MAXIMUM SURFACE SLOPE OF STORM WAVES FOR CROSS CHANNEL SERVICE
C MAXIMUM SURFACE SLOPE OF STORM WAVES FOR SERVICE IN HARBOURS & ESTUARIES
D, E, F, G MAXIMUM EFFECTIVE WAVE SLOPE FOR SHIP OF
22 FEET DRAUGHT CORRESPONDING TO CURVES ABOVE A
33 FEET DRAUGHT
16·5 FEET DRAUGHT CORRESPONDING TO CURVES ABOVE B
11 FEET DRAUGHT CORRESPONDING TO CURVES ABOVE C
NOTE—WAVES OF LONGER PERIODS MAY OCCUR THAN THE LIMIT INDICATED FOR THE VARIOUS REGIONS, BUT WILL NOT BE ASSOCIATED WITH GREAT SLOPE
SLOPE (DEGREES)
20°
10°
LIMIT FOR HARBOUR SERVICE
LIMIT FOR CROSS CHANNEL SERVICE
LIMIT FOR HOME TRADE & WESTERN MEDITERRANEAN
LIMIT FOR NORTH ATLANTIC
LIMIT FOR SOUTH ATLANTIC & SOUTH INDIAN OCEAN
0 2 4 6 8 10 12 14 16
REAL PERIOD OF WAVE (SECONDS)

Fig. 3. MAXIMUM EFFECTIVE WAVE SLOPE FOR SYNCHRONOUS ROLLING FOR NORTH AND SOUTH ATLANTIC, AND SOUTH INDIAN OCEANS


A FOR SHIPS HAVING A DRAUGHT OF 22 FEET
B FOR SHIPS HAVING A DRAUGHT OF 33 FEET
MAXIMUM EFFECTIVE WAVE SLOPE
10°
5°
20 KNOTS
15 KNOTS
10 KNOTS, NORTH ATLANTIC
5 KNOTS, N. ATLANTIC
5 KNOTS (SOUTH ATLANTIC & SOUTH INDIAN OCEANS)
0 1 2 3 4 5 6 7 8 9 10 11
PERIOD OF SHIP (SECONDS)

(8984 B)

Fig. 4. MAXIMUM EFFECTIVE SLOPE OF STORM WAVES FOR SYNCHRONOUS ROLLING

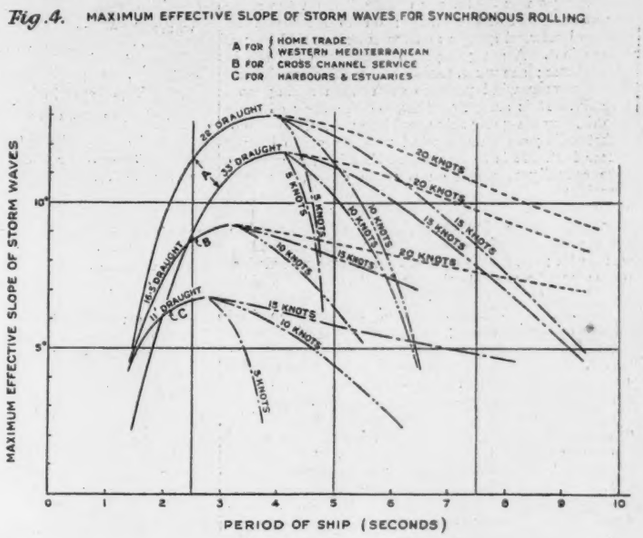
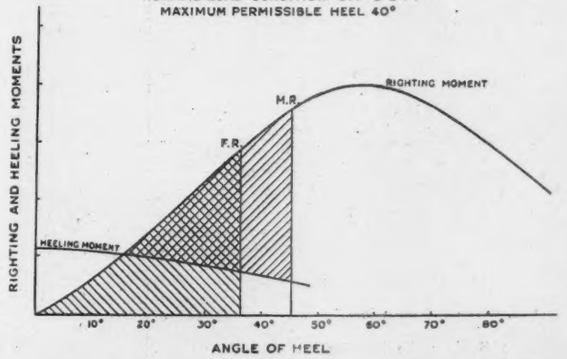


Fig. 5. ROLLING UNDER THE ACTION OF WIND AND WAVES
NORMAL LOAD CONDITION GM = 3·2 FT
MAXIMUM PERMISSIBLE HEEL 40°



of roll it is necessary to know the resistance to the rolling of the ship.

The present state of knowledge respecting the resistance experienced to the rolling of ships is far from satisfactory. Not only are very little data available, but those best qualified to speak on the subject throw doubt upon the sufficiency of the accepted method of presenting the results, in the two-power decremental equation.† As some knowledge of the resistance to rolling is essential if a standard of safe rolling is sought, this presents the chief point in the argument which is open to criticism. If this method should ever be adopted, it would prove useful to carry out systematic model experiments on merchant-ship forms in order to determine coefficients of resistance; the value of data so obtained would far outweigh the expense entailed. Nevertheless, the method holds good, even though there are little data available.

According to the accepted convention, when a ship rolls in still water, having been inclined and left to roll freely, the loss of angle of maximum heel per roll, from out to out, is given by :—

$$-\frac{\delta\theta}{\delta n} = a\theta + b\theta^2$$

roll, under conditions of unresisted synchronous rolling, is :—

$$\frac{\pi\theta_w}{2}$$

θ_w being the maximum effective wave-slope. The maximum angle of roll is reached when this increase is exactly counteracted by the decrease due to water resistance; this angle may thus be found from the equation :—

$$\frac{\pi\theta_w}{2} = a\theta + b\theta^2$$

The maximum angles of roll obtained by using this approximation agree sufficiently well with the results of the more exact calculations given by Dr. Froude in his 1896 paper read before the Institution.

The rolling of a ship has been seen to depend on the period of oscillation of the ship.

The period is given by the well-known formula

$$T = 0{\cdot}554\sqrt{\frac{K^2}{m}}$$

where T, = period of a single roll in seconds, K = radius of gyration in feet, m = metacentric height in feet. Of these factors K is not generally known; nevertheless its determination, whether by calculation or experiment, is as simple as that of the metacentric height. It is usual not to accept any calculation of the metacentric height as a sufficiently secure foundation for a finished report on the stability; but the report is based upon an inclining experiment made with the greatest care. Similarly the value of K used in determining the rolling period should be determined during the inclining experiment. This involves no more time and very little more trouble. While the deflection of the pendulum is being observed in order to determine the metacentric height, the number of oscillations per minute can be recorded by means of a stability meter. From the period so found, together with the value of metacentric height observed, the radius of gyration and the inertia of the ship follow directly.

It becomes necessary to examine the prevalence of weather conditions dangerous to the ship, and the degree of severity of their incidence. We are chiefly interested in the maximum wind pressure that is experienced at sea; but a certain interest attaches to the prevalence of the worst conditions, and to the degree of regularity of the wind during storms. In the first place, the wind is rarely, if ever, constant in direction for more than a few moments at a time, at a given locality. This is not always evident to casual observation, yet even in the regular trade wind regions, the direction of the wind is veering continually through a point or two. During storms the direction of the wind also varies continually. This has an important bearing on the generation of waves.

The effect of wind in increasing the dimensions of storm waves is very rapid. During a heavy gust the size of the waves often increases visibly. Thus, the irregularity of the direction of the wind causes irregularity in the size, and so in speed, of storm waves.

Further, at the same time in different adjacent localities the direction of the wind is not the same. Most violent storms are rotary in nature; the wind blows round about a moving centre. This limits the effective "fetch" of the wind, or the sea-room over which the generation of waves may be carried out. The maximum dimensions of storm waves are thus limited. In the North Atlantic, the maximum effective fetch is 700 or 800 miles, even though the breadth and length of the ocean are of larger extent.

Again, the velocity of the wind is not constant;

* "The Non-uniform Rolling of Ships," Trans. I.N.A., 1896. See ENGINEERING, vol. lxi, pages 554, 694, 725.

† "Rolling of Lightships," Baker and Idle, Trans. I.N.A., 1912. See ENGINEERING, vol. xciii, page 539.

it is even more irregular than the direction. This not only accentuates the irregularity of the storm waves, but has an even more important effect upon the pressure exerted.

A series of observations of wind pressures spread over a number of years (1901 to 1906) were made on the Forth Bridge. The observations were made at the centre and at each end of the bridge. The maximum pressures registered by the former gauge were 67 and 65 lb. per square foot; while the mean of the maximum pressures recorded for thirteen different storms during the period was 50 lb. per square foot. The mean pressures during the same storms registered by gauges at the ends of the bridge were 28 and 30 lb. per square foot. The maximum pressure recorded by these landward gauges was 55 lb. per square foot on the same day at each end of the bridge; on no other occasion did the landward gauges register more than 42 lb. per square foot. A sea-going ship must keep the sea in all weathers; she must, therefore, be able to withstand the maximum wind pressure even when rolling most severely. It is suggested that, on the basis of these records, any sea-going ship should be proved capable of withstanding a standard wind pressure of 55 lb. per square foot. It is to be noticed that higher pressures were actually recorded on a small gauge, yet it is thought that these must have been of short duration, and probably very local in extent, and inapplicable to the wide expanse of wind catchment offered by a ship. On the other hand, the mean of thirteen observations was 50 lb.; and pressures of 55 lb. were recorded at points more than a mile apart under the influence of the land during the same storm.

The important phenomena of wave-motion that require notice in dealing with the rolling of ships are regularity in point of size and period of the successive waves, the prevalence of waves of periods with which synchronism is possible, and the maximum wave-slopes associated with waves of any given period.

Scientific observations of the maximum dimensions of storm waves at sea are not numerous, nor are they always to be taken at their face value, as a regularly organised survey has never been carried out all over the world; those available arise only from chance conjunction of opportunity and circumstances. Reliance is placed here upon the published work of Dr. Vaughan Cornish ("Waves of the Sea and Other Water Waves") and Mr. Idle (*The Engineer*, April, 1911). Apart from the regularity of the wind, the general conditions governing the maximum size of storm waves in any locality are the fetch or sea-room to windward and the speed of the wind. Mr. Stevenson, the lighthouse builder, found that the maximum height of storm waves, in feet, is one and a-half times the square root of the fetch in nautical miles. This gives, for a harbour 9 miles long, a wave height of $4\frac{1}{2}$ ft.; for the North Sea, with a fetch of 300 miles, a height of 26 ft.; for the North Atlantic, with an effective fetch of 700 to 800 miles, a height of 40 ft.

From Dr. Cornish's and Mr. Idle's observations, Fig. 2 has been constructed.

Curve A gives the maximum surface slope of storm waves in the open sea, plotted on a base of wave period. This curve applies generally, but the maximum period of storm waves having the maximum wave-slope in the North Atlantic does not exceed 10 seconds, because of the rotary nature of the prevalent storms; this point is marked in the figure. There is also shown a limiting period for waves in the North Sea and Western Mediterranean, where the fetch is limited by the presence of land.

Curve B gives the limiting wave-slope for cross-Channel services of not more than 100 miles based on the former curve, with a limitation of wind velocity as suggested above.

Curve C is an approximate limit for ships working only in harbours, estuaries, and used for short excursions, derived in a similar manner.

These curves relate to the slope of the wave at the surface; the effective wave-slope is smaller, because the ship penetrates into regions where the orbits described by the water particles are smaller. It may be taken as the slope of the sub-surface, which when at rest passes through the centre of buoyancy. This can readily be calculated from the surface slope.

Curves D and E show the maximum effective wave-slopes for ships of 33 ft. and 22 ft. draught, corresponding to curve A.

Curve F gives the maximum effective wave-slope for a draught of 16·5 ft. derived from curve B; and curve G that for a draught of 11 ft. derived from curve C. (The distance of the centre of buoyancy being assumed 0·45 of the draught below the water-line in each case.)

In Figs. 3 and 4 the curves given in Fig. 2 have been replotted on a base of rolling period of ship in synchronism with the waves; they therefore give the maximum effective wave-slope which a ship of given period can encounter in service under the worst conditions of weather, and thus permit the maximum possible angle of forced rolling to be calculated directly by the formula given above. In these figures are also plotted curves showing the effect of course and speed of the ship in modifying the apparent wave-slope and apparent period of the waves; for, if the period of the ship lies beyond the possible range of synchronism applicable to her service, synchronism may yet arise when steaming with a fair wind and athwart the seas. In devising these curves the relation between the apparent and real periods of the waves has been taken as:—

$$\frac{T_a}{T_w} = \frac{1}{1 \pm \frac{V_s}{V_w} \sin \beta}$$

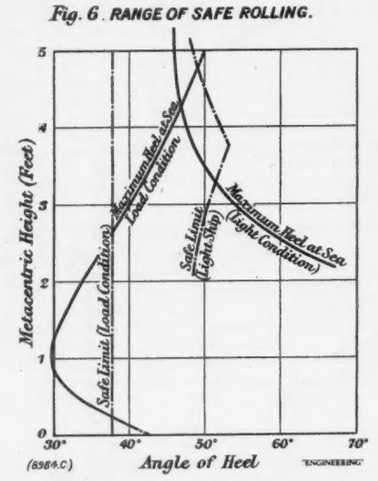
and the apparent wave-slope as:—

$$\theta_a = \theta_w \times \cos \beta$$

where T_w = real period of waves,
T_a = apparent period of waves,
V_s = speed of ship,
V_w = speed of wave,
θ_w = real effective wave-slope,
θ_a = apparent effective wave-slope.
β = angle of encounter.

In using these subsidiary curves, a reduction in speed below the normal sea-speed may be accepted, for even with a fair wind the speed will be reduced in such bad conditions as are here assumed. When the natural period of the ship is so great that no storm waves having the same period can be encountered during the given voyage, that is, when the ship's period plots in Fig. 3 to the right of the limit of the slope curve, the maximum rolling of the ship will be reduced. In order to estimate with exactness the angle of roll attained, the process indicated by Dr. R. E. Froude may be followed. A rough approximation, however, may be made by the following empirical formula:—

Fig. 6. RANGE OF SAFE ROLLING.



Let r = ratio of ship's period to the limiting period of storm-waves;
θ = angle of synchronous rolling calculated by the ordinary method, assuming that synchronism occurs with waves having an effective slope appropriate to storm-waves of the limiting period;
w = this effective wave-slope;
a = maximum angle of heel from the normal of the wave under the given conditions.

Then

$$r^{2 \cdot 5} \log (a - w) = \log (\theta - w).$$

The value of a so found is within two or three degrees of the correct value; this has been checked against the values of the maximum angles of resisted rolling given in Dr. Froude's 1896 paper in his Table 3. This formula has been used for the lower parts of the curves in Fig. 6.

The ship must not exceed the safe range of heel when rolling in synchronism with waves of the maximum effective wave-slope, and at the same time exposed to the standard maximum wind pressure. The maximum heel is found by constructing two curves of heeling moment and of righting moment (see Fig. 5). F R marks the angle of synchronous rolling under no wind pressure. The area of the curve between the ordinate and the base from the origin, is the work done on the ship in rolling to the maximum angle of heel. If the base line is now transferred to the heeling moment curve, and an ordinate, M R, determined, which cuts off the same area, measuring from the intersection of the two curves, then M R gives the maximum angle of heel, under wind pressure and synchronous rolling.

If the calculation is performed for a ship at a given displacement, under the standard conditions of wind and waves, over a range of metacentric height and period of rolling, a series of maximum angles of heel is obtained. These can be plotted, as in Fig. 6, on a base of metacentric height. The curve so obtained crosses the safe range of heel appropriate to the given draught at two points, in general. Where the curve lies below the safe range of heel, the ship will never reach the limit of safety under any conditions at sea. The points of intersection give values of maximum and minimum safe metacentric heights for the given draught.

In Fig. 1, curves E and D give the maximum and minimum safe metacentric heights plotted on a base of draught at the time of sailing, but these have been corrected to satisfy the condition that the consumption of the varying load will not bring the metacentric height, at any time during the projected voyage, outside the safe range. The curves so determined are not absolute, a greater minimum metacentric height may be required to conform with curves A and C in the same figure, which represents the minimum margin to ensure initial stability; while a smaller maximum metacentric height may be required if bulk cargo is carried in the upper 'tween decks (see Curve F).

Professor Jenkins, in 1887, read a paper before this Institution on Shifting Cargoes. In it he showed that at any point in a free surface of cargo above the centre of gravity, the angle of repose is virtually reduced, by the acceleration due to rolling motion. If, therefore, a free surface forms through the settling of the cargo, shifting will certainly take place at much smaller angles of heel than are reached if the ship is subjected to synchronous rolling. A great simplification can be made in the application of Professor Jenkins's analysis by using the expression $-\frac{\pi^2}{T_s^2} \times \theta$ for the angular acceleration, instead of the more general expression involving the righting lever; this approximation is nowadays usually accepted, and is of the same degree as that used in rolling calculations.

In order to eliminate, as far as possible, any chance of the cargo shifting, it should be arranged that any ship carrying bulk cargo at a higher level than the centre of gravity of the ship will not be at sea with a rolling period within the range of possible synchronism. From Fig. 3, it appears that in an ordinary slow cargo ship the period should never be less than 10 seconds. Curve F, in Fig. 1, shows the maximum metacentric height, on a base of draught, which will ensure that the period during the projected voyage will never fall below this limit.

In this way a standard of safety applicable to any ship has been arrived at. If a series of curves such as are illustrated in Fig. 1 are drawn up for any given ship, it can be said that under no circumstances will the stability be unsafe from the beginning to the end of any voyage commenced with a metacentric height lying between the maximum and minimum values appropriate to the draught at the time of sailing.

(To be continued.)

CATALOGUES.

Boilers.—The Inglis Boiler Syndicate, Limited, 83, Renfield-street, Glasgow, have sent us an illustrated catalogue of their land and marine boilers with three-way combustion chambers. These boilers have corrugated heating surfaces and may have two, three, or four furnaces. They are shown fitted with mechanical stokers and superheaters.

Electric Welding.—Messrs. British Brown-Boveri, Limited, Trafalgar House, Waterloo-place, London, S.W., have sent us a circular illustrating a portable arc welding set, in which a special control system is fitted for economising the current. We have also received a copy of the Brown-Boveri Review containing illustrated articles on turbo-compressors and several items of electrical plant.

Protection of Electrical Machinery.—A new catalogue dealing with systems of protection for alternating-current generators, transformers and feeders, is to hand from the British Thomson-Houston Company, Limited, Rugby. The subject is methodically and fully discussed with diagrams, and much valuable technical and practical information is given in the catalogue.

Canning Machinery.—A number of machines used in the process of canning vegetables, fruits, preserves, fish, butter, meat and other foodstuffs, are illustrated and described in "Cannery Notes," a house magazine issued by the Peerless Husker Company and Sprague-Sells Corporation, Dearborn-street, Chicago, U.S.A. The term "cannery" is used to include the whole process of selecting, preparing and tinning the foods.

Dredging and Excavating Machinery, Cranes, &c.—A number of examples of grab-type machines for dredging, excavating, and transferring loose material are described in a catalogue received from Messrs. Priestman Brothers, Limited, Hull. Eighty-five different forms of bucket are illustrated as well as hopper steamships, barge and pontoon equipments, rail and road wheeled trucks on which the machinery is mounted. A catalogue dealing especially with locomotive steam cranes is also to hand.